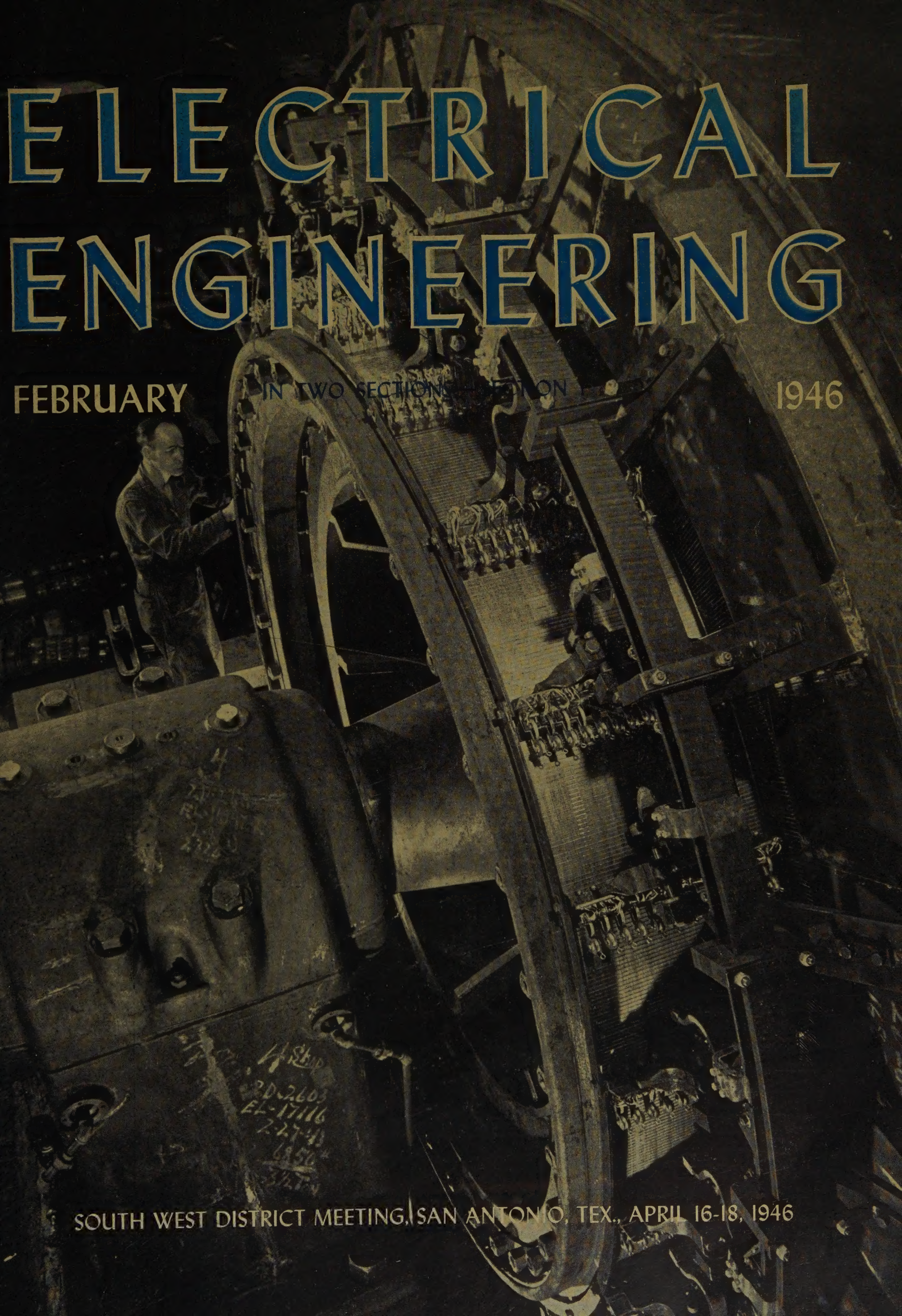
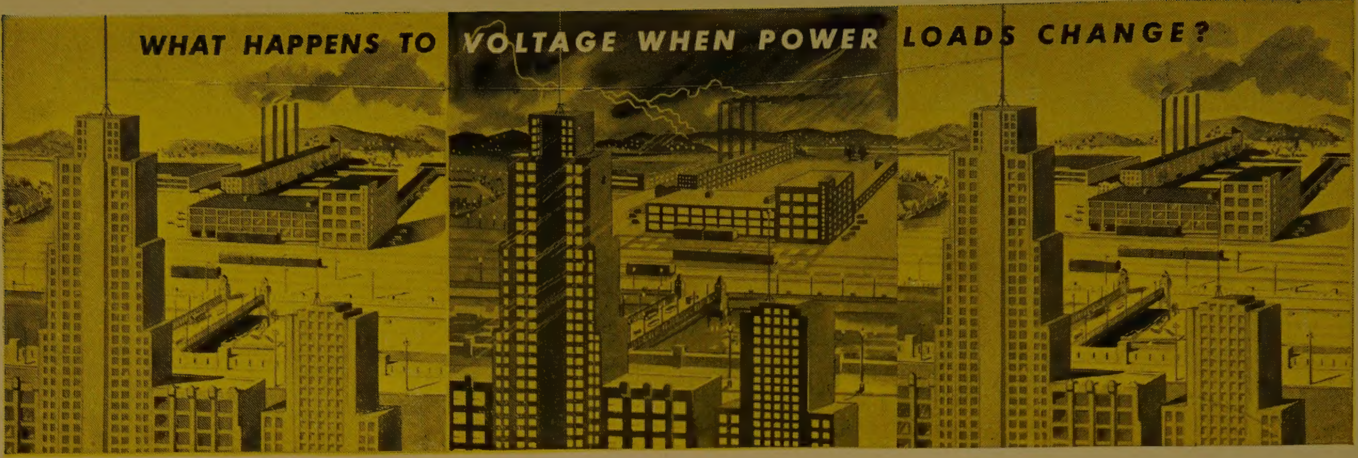
ELECTRICAL ENGINEERING

FEBRUARY IN TWO SECTIONS—SECTION 1946



SOUTH WEST DISTRICT MEETING, SAN ANTONIO, TEX., APRIL 16-18, 1946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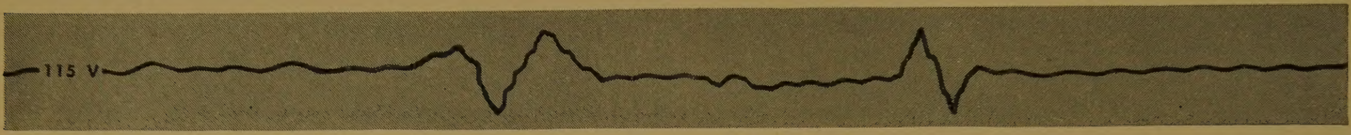

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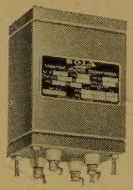

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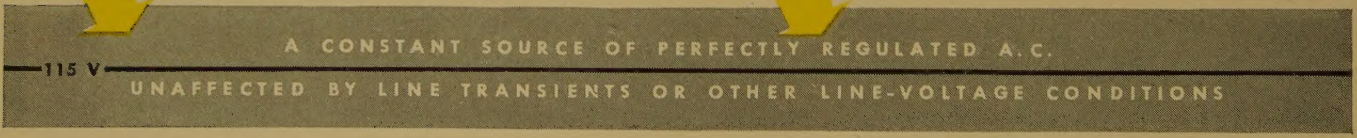

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ELECTRICAL ENGINEERING

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1946

The Cover: A 7,000-horsepower steel-mill motor which can produce 19,000 horsepower at short-time peak output and is capable of reversing at base speed in less than two seconds.
Allis-Chalmers photo

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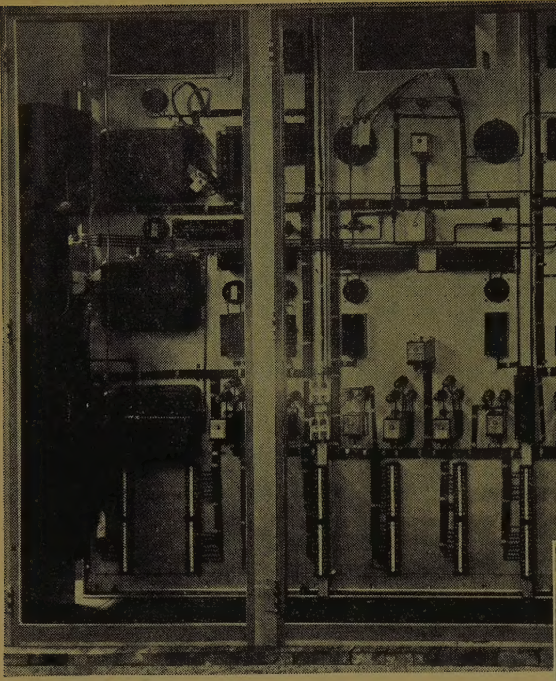

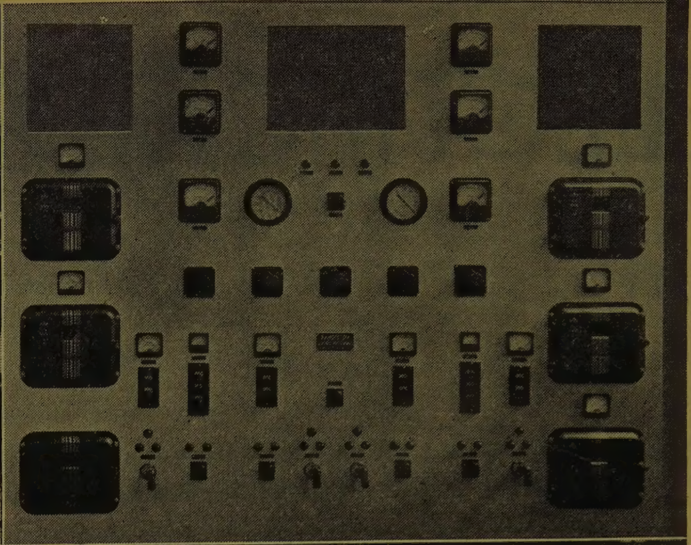

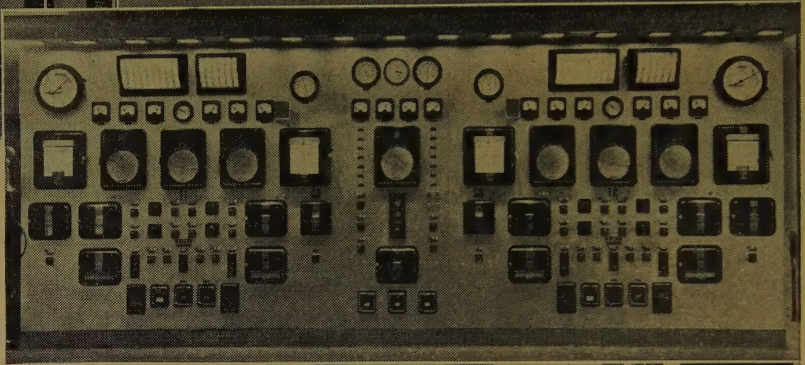

Back and front views, at our plant, of Metermax Combustion Control section of a complete L&N boiler gauge board for Picway Station, Columbus & Southern Ohio Electric Co. Right—Two-boiler L&N Control Board installed at Westover Station, New York State Electric & Gas Corp.

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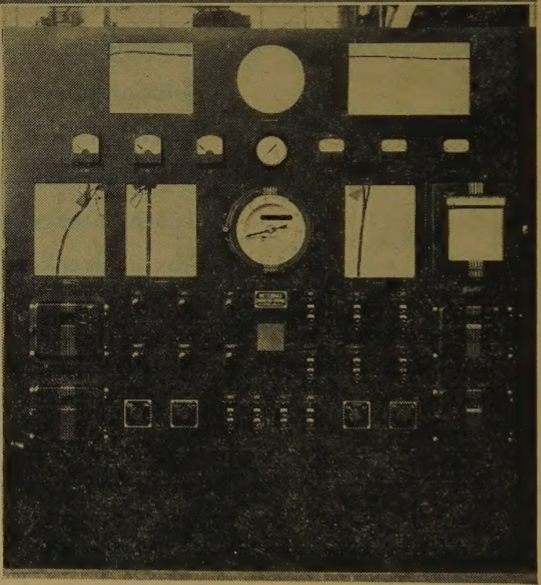

Labelled in Russian, this is one of eight boiler boards shipped as shown to U.S.S.R. Metermax Controllers and Micromax Instruments are mounted. Wiring for separately-shipped equipment can be seen, cabled and tagged, in cut-outs.

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HIGH LIGHTS . . . .

Production Delays. In terms of late issues, the January issue of *Electrical Engineering* set an unenviable record. Although schedules call for completion of mailing from the printing plant at Easton, Pa., by the fifth of the month, the January issue did not begin to go into the mail until the 21st. In addition to currently normal printing production delays, the paper supplied for the January issue turned out to be intermixed with sheets of substandard size which required hand-culling as they went through the presses and folders, to prevent the distribution of defective copies of *Electrical Engineering*. Some of these delays will carry over and adversely affect the completion of this issue.

Record Convention. With an as-yet-unverified total registration of approximately 2,500, the 1946 winter convention in New York, N. Y., easily surpassed the previous winter convention high mark of 1,931, which was established in Philadelphia, Pa., in 1941. A complete report of the convention is scheduled for March (*page 84*).

Nominees. J. E. Housley (F '43) nominee for AIEE president for the 1946–47 term, heads the list of candidates for Institute offices announced by the nominating committee (*page 84*).

1945 Indexes. The annual indexes to *Electrical Engineering* and *AIEE Transactions* for volume 64, 1945, are being distributed as section 2 of this issue, thereby marking resumption of a service that had to be foregone with the 1944 indexes because of paper restrictions. Although the regular indexes were produced for that year, copies were furnished only on request.

Circuit Breaker for 400 Cycles. Considerable thought is being given to the use of 400-cycle a-c systems in aircraft. A necessary device for such systems is a suitable circuit breaker; a lightweight 3-phase unit has been produced which performs satisfactorily in tests at atmospheric pressures corresponding to an altitude of 55,000 feet (*Transactions pages 58–60*).

Father of Electricity. For his contributions to electrical science Benjamin Franklin often is referred to as the father of electricity. Although there were some earlier nvestigations of electrical phenomena it is from the experiments and discoveries of Franklin and his contemporaries that modern theories of electricity are derived (*pages 57–64*).

West Point Laboratory. Of possible interest to other institutions planning facilities for instruction in electronics is the laboratory of the United States Military Academy, in which facilities are provided for as many as 140 students to conduct the same experiment, or for as many as 12 groups to conduct different experiments simultaneously with power supplied from central sources (*pages 75–80*).

January Cover. Astronomers and navigators among the membership were quick to chide *Electrical Engineering* for "reversing the heavens" in the picture carried on the January cover. Critics are correct, astronomically, but the cover nevertheless correctly pictured the refurbished decoration actually on the ceiling of main concourse of the Grand Central Station in New York City.

Acceptance Sampling. Much acceptance inspection is conducted on a sampling basis and, though some risks and errors are unavailable, systems incorporating various sampling methods have been developed which are suited peculiarly to certain types of inspection (*pages 81–3*).

Electric Measuring Instruments. Many recent developments in electric measuring and controlling instruments would appear to point the way to obsolescence for mechanical types of similar instruments. The electronic instruments undoubtedly possess advantages but they also have characteristics which make them impractical for some purposes. Further mechanical improvements probably will reduce the competition to one based on economic factors (*pages 66–74*).

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Coast Guard Cutters. Thirteen turbine-electric a-c vessels will constitute the fleet of cutters now under construction by the United States Coast Guard. These vessels will have complete automatic control from the pilot house and either automatic or manual control from the engine room (*page 64*).

Letters. The use of glow lamps in a monitoring instrument for d-c motors and certain objections to recently issued reports on the impedances of synchronous machines are among the subjects included in the "Letters to the Editor" columns of this issue (*pages 95–7*).

Lightning Performance. Further data have been gathered on the lightning performance of 220-kv transmission lines to supplement a study first made in 1935. By means of a questionnaire, 13 companies participated in the present compilation of information (*Transactions pages 70–6*).

Industrial Systems. Introduction of fluorescent lamps operating on voltages higher than 120 volts for lighting industrial plants makes practicable the operation of combined lighting and power systems, with resultant economy (*Transactions pages 76–83*)

Correction. Due to a printer's error in the second line on page 24 of *Electrical Engineering* for January, "Statistical Methods in Quality Control—VIII," the expression $\bar{\bar{X}}\times 530$ milligrams appears incorrectly. This expression should have read $\bar{\bar{X}}'\times 530$ milligrams.

Network Protector. Low-voltage a-c network distribution systems require devices called network protectors to isolate the distribution transformers in case of faults. A new protector that is proof against submersion in case of flooding of its vault is designed for a continuous rating of 3,000 amperes and an interrupting rating of 40,000 amperes (*Transactions pages 41–6*).

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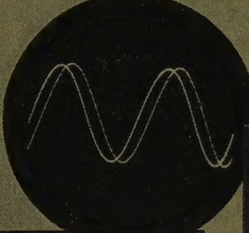
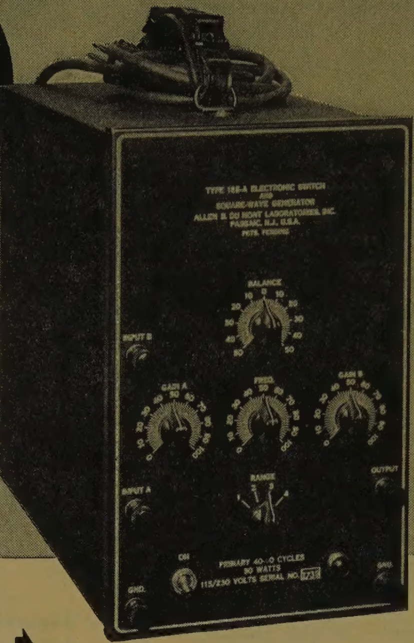
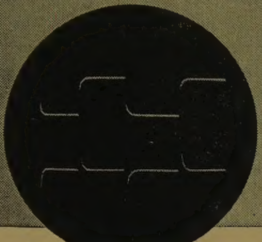
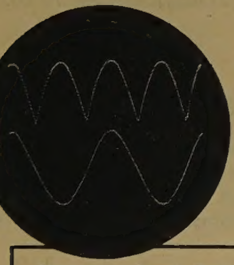


Phase shift introduced through an R-C network.





Square-wave input (top) to differentiator network, showing differentiated output (below).



Sine-wave input (bottom) to full-wave rectifier showing rectified output (top).

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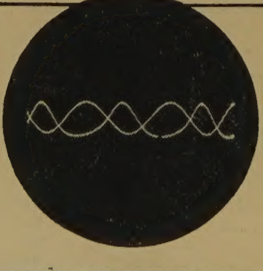
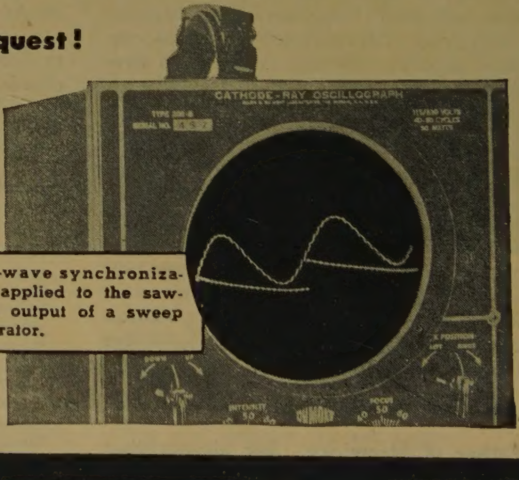
Comparison of input and output of phase inverter. Distortion in phase inverter is evident.





Sine-wave synchronization applied to the sawtooth output of a sweep generator.

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Franklin's Role in Electrical Science

MALCOLM MacLAREN
MEMBER AIEE

Prior to the 18th century little serious scientific interest had been aroused by electrical phenomena. However, when Benjamin Franklin, in 1746, began experimenting with electrical effects he initiated much productive activity in the field and, in fact, in later years was known as the "father of electricity." This article presents a discussion of early electrical discoveries by Franklin and his contemporaries. Excerpts from letters and publications then current afford an insight into scientific thought of the period.

WHEN BENJAMIN FRANKLIN drew the lightning from the clouds and identified it with the then little understood medium called "electricity," he initiated a movement that has led to untold blessings for mankind. The significance of this discovery was not so much in its intrinsic importance but rather in the unique personality of the discoverer and in the enthusiasm with which he carried on his studies in a field that up to that time had received little consideration from the scientific world.

In the light of our present knowledge many of Franklin's experiments seem quite trivial in character, and they impressed some of his friends in the same way. The wide range of his activities is illustrated by the interest he showed in early experiments in aviation. When questioned as to any possible use that could be derived from flying a balloon, he replied, "What is the use of a new-born baby?" He evidently had the same faith in the future development of the electrical industry, which was his major scientific interest, and possibly he made the same reply to those who questioned his interest in this field for in the later years of his life he frequently was called the father of electricity.[1]

Benjamin Franklin was born in Boston, Mass., on January 17, 1706, into a family of 17 children, 7 of whom were children of his father's first wife. Benjamin was the youngest son in this large group and he had the unusual distinction of completing a direct succession of youngest sons through five generations. His formal education was limited to only two years of conventional school instruction and at the age of ten Benjamin became an assistant to his father who was a tallow-chandler and soap-boiler. In this business he was employed in cutting wicks, filling candle molds, and acting as general errand boy for the establishment.

Living in the port of Boston where ships arrived from all parts of the world, and being galled by the confining nature of his work, Benjamin was tempted strongly to abandon his home for a seafaring life. However, his brother James arrived from England with printing press and equipment that enabled him to build up a business as printer and publisher and Benjamin acquired a new interest. He was apprenticed to James and served with him until he was 17 years old. Here he became an expert typesetter and began his career as a writer, though he later confessed that his early attempts "were wretched stuff in the Grub-street ballad style."

Benjamin's business relations with his brother were not always peaceful and after many disputes he left James and boarded a ship for New York in order to be entirely free from his influences. He arrived in Philadelphia, Pa., in October 1723 after crossing New Jersey, largely on foot. He came without any knowledge of the town and with only a few shillings in his pocket but with his trade as a profession he readily found employment. His genius for making friends soon became apparent and within a year after his arrival he had acquired many among whom was Sir William Keith, the governor of the province, who took him under his patronage. It was at Keith's suggestion that Franklin made his first visit to London where he remained for two years.

Upon his return to Philadelphia Franklin resumed his profession as publisher. Through his writings, and by his industry and good sense, he became the recognized head of journalism in the Colonies. In 1731 he established the first circulating library in America. The next year he started his "Poor Richard's Almanack" which was continued for 25 years and which attained great popularity and wide circulation.

In 1736 Franklin began his political career by becoming a member of the General Assembly. At about this time he organized the first police force and fire department in the Colonies and provided for the paving of the principal streets in Philadelphia. A few years later he was active in movements for starting a hospital, for founding the American Philosophical Society, and for establishing an academy which later became the

---

Essential substance of "Early Electrical Discoveries by Benjamin Franklin and His Contemporaries" which appeared in the *Journal* of the Franklin Institute, volume 240, July 1945.

Malcolm MacLaren was professor emeritus, Princeton University, Princeton, N. J., at the time of his death on September 24, 1945 (*EE, Nov '45, p 415*).

University of Pennsylvania. It was not until 1746 that he first became interested in the study of electricity. He described how this occurred in the following words:

> "In 1746 being in Boston, I met there with a Doctor Spence, who had lately arrived from Scotland, and he showed me some electric experiments. They were imperfectly performed, as he was not very expert; but being a subject quite new to me, they equally surprised and pleased me. Soon after my return to Philadelphia, our library company received from Mr. Peter Collinson, Fellow of the Royal Society of London, a present of a glass tube, with some account of the use of it in making such experiments. I eagerly seized the opportunity of repeating what I had seen in Boston and by much practice acquired great readiness in performing those, also, which we had an account from England, adding a number of new ones. I say with much practice for my house was continually full, for some time, with persons who came to see these new wonders.
>
> "To divide a little this incumbrance among my friends I caused a number of similar tubes to be blown in our glass-house, with which they furnished themselves, so that at length we had several performances. Among these, the principal was Mr. Kinnersley, an ingenious neighbor, who being out of business, I encouraged him to undertake showing the experiments for money, and drew up for him two lectures, in which the experiments were arranged in such order, and accompanied with explanations in such a method, as that the foregoing should assist in comprehending the following. He procured an elegant apparatus for the purpose, in which all the little machines that I had roughly made for myself were neatly formed by instrument makers. His lectures were well attended, and gave great satisfaction; and after some time he went through the colonies, exhibiting them in every capital town, and picked up some money."[2]

As has been noted previously it was not until Franklin's day that scientists began to take a serious interest in electrical phenomena. However, it would be appropriate to consider briefly what electrical discoveries had been made up to that time. It long had been known that certain bodies, later called nonconductors, could receive an electrical charge through friction. This charge could be detected either by a prickling sensation produced by contact of the charge with one's body or by bringing the charge into the presence of shreds of silk, paper, or other light material. These first would be attracted to the surface of the charged body and, after coming in contact with that surface, they would be repelled from it. It also was known that these light objects, when charged from different sources, behaved in an uncertain manner when brought close to each other. In some cases there was an attraction between them and in others a repulsion. When they received their charge from the same source they always were repelled. This discovery led to the development of the first electric instrument which was known as an electroscope. This electroscope took various forms but one of the best known consisted of two strips of gold leaf inclosed in a glass bottle. They were suspended from a common metal terminal which extended through the neck of the bottle so that when a charged body was brought into contact with the terminal its presence was indicated by a separation of the gold leaves.

In 1729 Stephen Gray, a member of the Royal Society of England, made experiments to determine the difference in the behavior of conductors and nonconductors for transmitting an electrical charge. He used lines of silk, iron, and brass which gradually were extended to a length of about 900 feet, and he employed a brass-leaf electroscope as a detector.[3]

At about the same time Charles Francois de Cisternay du Fay, a member of the Royal Academy of France, developed his two-fluid theory of electricity. He had noticed the afore-mentioned capricious action of charged bodies, namely that in some cases such bodies were attracted to each other while in other cases they were repelled. He explained this action by the principle that there were two kinds of electricity. One, which he called vitreous electricity, could be produced by friction upon glass, rock-crystal, precious stones, hair of animals, wool, and many other bodies. The other he called resinous electricity. It was produced from amber, copal, gum-lack, silk, thread, paper, and a vast number of other substances.[4]

In 1745 the Leyden jar or phial was developed, so named through the work of Pieter van Musschenbroek, professor of philosophy and mathematics at the University of Leyden. He had observed that electrified bodies soon lost their charge when exposed to the air and conceived the idea that more stable conditions could be obtained if he could devise means for enclosing the charge in a nonconductor. He partly filled a glass bottle with water while his assistant held it in his hand. During the manipulation of the circuit when it was being charged the assistant received a telling shock in his hand and arm which clearly demonstrated the effectiveness of the device. William Watson, a member of the Royal Society of London, brought the jar into its modern form by coating both the inside and outside of the jar with metal.[5]

The development of the Leyden jar provided means for producing much stronger electrical effects than previously had been possible. Also, more powerful generators were designed so that the way was paved for a considerable advance in the study of electricity. This was reflected by a great increase in the number of papers recounting experiments in electricity that were appearing in the technical papers, especially in England and France. Martin Folkes, president of the Royal Society of London, made the following comment on this situation:

> "Electricity seems to furnish an inexhaustible fund for inquiry and such phenomena so various and so wonderful, can arise only from causes very great and extensive, and such as must have been designed by the Almighty author of nature for the production of very great effects."[6]

William Watson in England and others on the continent of Europe found that light spirits could be ignited by an electrical discharge and that visible sparks could be seen that were accompanied by sounds resembling a miniature thunderstorm.[7] Watson then started a study of the electrical conductivity of different substances that was continued for several years. He pointed out the difference in the behavior of conductors and non-conductors and showed that metals were best for conducting a charge. In 1747 he made a true electrical transmission experiment. He laid a wire across Westminster Bridge in London and stationed an observer on each bank of the river. The observer on the Westminster side held one terminal of the wire in one hand and made contact with the river by inserting an iron rod which he held in his other hand into the water. The observer on the Surry shore took hold of the wire with one hand and grasped with his other a large phial filled with iron filings and coated with sheet lead highly electrified from a glass globe installed in a neighboring house. A third observer, standing near the second, dipped an iron rod which he held in one hand into the water while he touched with his other hand the iron hook of the phial which made contact with the iron filings. As soon as this contact was made the charge snapped and was felt by each of the three observers. This experiment was repeated several times with equal success but during the progress of the tests a large crowd of spectators had collected on the bridge and had caused considerable annoyance by breaking the transmission wire and in other ways interrupting the experiment. The total length of the circuit, including the water, was about 2,400 feet.

Watson decided to continue these tests but in order to avoid interference from a curious audience he moved his equipment into the open country. He varied his experiment by using an overhead wire for his outgoing circuit and a bare wire laid on the ground for the return circuit. Starting with a total length of line of about one mile, he gradually increased this to nine miles and received signals successfully in each case. He then made an attempt to determine the velocity of the electrical transmission. A gun was fired at the far end of the line at the same moment that a charge from a Leyden jar was introduced into the circuit. The difference in the time between the reception of the charge and that of the sound of the gun was noted and knowing the velocity of sound it was estimated that the velocity of transmission of the electrical charge was practically instantaneous compared with that of sound.[8]

While Watson was conducting these transmission experiments he also was making many others in order to obtain more specific information regarding the properties of electricity. He finally concluded that what we call electricity is a very subtile and elastic fluid common to all bodies which in their natural state have the same electrical density, that this fluid manifests itself only when bodies capable of receiving more than their natural share are operated upon by certain well-known methods, and that they show their electrical condition by attracting or repelling light objects, by a snapping sound, or by sparks, and in fact may be capable of affecting any of our senses. Watson also concluded that no snapping is observed when two bodies have the same density, that the intensity of the snapping is determined by the difference in the density of the two objects, and that certain bodies which he called electrics have the essential property of transmitting electricity.[9]

Within a year from the time that Franklin began to be interested in the study of electricity he received, from Europe, his first recognition as a scientist. The first reference to his scientific work to appear in the *Philosophical Transactions* was given by William Watson in the paper referred to in the foregoing. He stated that Mr. Collinson recently had received a paper concerning electricity from an ingenious gentleman, Mr. Franklin, a friend of his in Pennsylvania. The paper was dated June 1, 1747. By a curious coincidence which sometimes occurs in scientific investigations, two students, entirely without knowledge of each other's work, covered much the same ground but did not always reach the same conclusions. In this case, while Watson was carrying on his research in London, Franklin was making his experiments in Philadelphia. He gave his results in the paper which he sent to Mr. Collinson and which was presented to the Royal Society. Franklin designated the two electrical states that a body might receive as the result of a positive or negative charge, terms that have continued in use to the present day.[10]

In July 1747 Franklin investigated the effect of different forms of terminals upon the discharge of a Leyden jar. For one terminal he used a cast iron shot about four inches in diameter. When he approached this with the other terminal which consisted of a sharply pointed bodkin the discharge took place through an air gap of six to eight inches. If he substituted a blunt body for the bodkin, the terminals could be brought to one inch of each other before the discharge took place.[11] This experiment later guided Franklin in the design of the terminals for his lightning rods.

It was about this time that Franklin began his study of lightning with the definite purpose of identifying it with electricity. Other scientists had noted that the vivid flash accompanied by a crackling sound which occurred on the discharge of a group of highly charged Leyden jars was quite suggestive of a flash of lightning followed by thunder. At about this same time Abbé Jean Antoine Nollet, professor of physics at the University of Paris and member of the French Academy, a prolific writer on electrical matters, expressed the hope that someone would attempt to prove that thunder in the hands of nature is what electricity is in ours and that the wonders which we now exhibit at our pleasure are but little imitations of those effects that frighten us.

In the spring of 1748 Franklin wrote to Peter Collinson describing experiments he had made on charging and discharging Leyden jars and in studying the effect of grouping them in different combinations. But he appeared to be rather discouraged at the futility of this work for he closed his letter with the following paragraph:

> "Chagrined a little that we have hitherto been able to produce nothing in the way of use to mankind and hot weather coming on, when electrical experiments are not so agreeable, 'tis proposed to put an end to them for the season, somewhat humorously in a party of pleasure on the banks of the Skuylkil. Spirits at the same time are to be fired by a spark sent from side to side through the river, without any other conductor than the water—an experiment which we some time since performed, to the amazement of many. A turkey is to be killed for our dinner by the electric shock, and roasted by the electric jack, before a fire kindled by the electrified bottle, when the healths of all the famous electricians in England, Holland, France, and Germany are to be drank in electrified bumpers, under the discharge of guns from the electrified battery."[12]

Answering a letter from this same English friend he wrote later in 1748 expressing his pleasure on hearing that the paper which he had presented the previous year had met with the approval of the Royal Society and also that his ingenious friend Mr. Watson was preparing another paper on the same subject. He stated that he himself lately had been doing very little experimental work in electricity but that he hoped to take it up again during the following winter, "as the approaching peace gives us a prospect of being more easy in our minds."[13]

Franklin's reference to hostilities concerned an early stage in the French and Indian war with the Colonies, and while his hope for an early peace was not realized he did find time to resume his electrical studies. In the summers of 1749 and 1750 he wrote to his English friend, Peter Collinson, giving him many examples of the way in which lightning produced effects similar to those from a heavily charged Leyden jar. He also suggested a theory to explain how clouds, as they collected before a storm, might draw electricity from the earth. He confessed, though, that he would not place too much reliance upon this theory and then made the following comments:

> "It is not of much importance to us to know the manner in which nature exerts her laws; 'tis enough if we know the laws themselves, 'tis of real use to know that china left in the air unsupported will fall and break; but how it comes to fall and why it breaks are matters of speculation; 'tis a pleasure indeed to know them, but we can preserve china without it. Thus in the present case to know the power of points in assisting in the discharge of Leyden jars may be of some use to mankind in preserving houses, churches, ships, and so forth, from the strokes of lightning by directing us to fix on the highest parts of those edifices, upright rods of iron made sharp as a needle and gilt to prevent rusting and from the foot of those rods, a wire down the outside of the building into the ground, or down around one of the shrouds of a ship and down her side till it reaches the water."[14]

This appears to be the first time that Franklin had given an account of his famous lightning rod which soon came into wide usage, not only throughout the Colonies, but also in Europe, and since that time has been of inestimable value in the protection of property.

Franklin then went on to describe an experiment for proving definitely whether or not lightning was an electrical discharge. This later became known as the Philadelphia experiment and as it created a real sensation in the scientific world of that day, Franklin's description of it is given in full:

> "To determine whether the clouds that contain lightning are electrified or not, I propose an experiment to be tried where it may be done conveniently. On the top of some high tower or steeple place a kind of sentry-box big enough to contain a man and an electrical stand. From the middle of the stand let an iron rod rise and pass bending out of the door and then upright for 20 to 30 feet, pointed very sharp at the end. If the electric stand be kept clean and dry a man standing on it, when such

Franklin Institute mural painted by Thornton Oakley

HE TORE THE LIGHTNING FROM THE SKY
AND THE SCEPTER FROM THE TYRANTS

clouds are passing low, might be electrified and afford sparks, the rod drawing fire to him from a cloud. If any danger to the man should be apprehended (though I think there should be none), let him stand on the floor of his box and then bring near to the rod the loop of a wire that has one end fastened to the leads, he holding it by a wax handle, so the sparks if the rod is electrified, will strike from the rod to the wire and not affect him."[15]

When Collinson showed Franklin's letter to other members of the Royal Society they ridiculed his theory and said that it was not worthy of publication in their *Transactions*. However, in the following year a short and very guarded note by William Watson was published in the *Transactions* in which Watson said that Franklin had a very thorough knowledge of electrical matters, that he had the head to conceive and the hands to execute his experiments, but that he held some few opinions with which Watson could not agree.[16]

Franklin Institute mural painted by Thornton Oakley

In the summer of 1752 Abbé Nollet saw a translation of Franklin's paper describing his Philadelphia experiments. At first he could not believe that such a work had come out of America. He said that it must have been fabricated by his enemies in Paris to discredit him for the theory which he had developed regarding the nature of electricity. Afterwards, when he had been assured that there really existed such a person as Benjamin Franklin in Philadelphia, he wrote a long letter to Franklin defending his own theory and denying the validity of Franklin's experiments and the conclusions deduced from them.[17,18]

Franklin first was tempted to answer Nollet's attack, but instead he decided to let his papers shift for themselves believing it better to spend any time that he could spare from his public business on new experiments rather than in debate about those already made. He found that he was justified fully in this decision for, during the summer of 1752, other scientists throughout Europe repeated Franklin's experiments and proved the validity of his theories which then became accepted universally.[19] De le Monnier, in Paris, repeated his experiments with an iron rod connected to the earth through an iron wire. He found that it was not necessary to provide a sharp point on the rod and that it even might be placed horizontally. A man thus electrified could set fire to spirits of wine with his finger and repeat almost all of the useful experiments of artificial electricity.[20] LeRoy and Delibard showed the Philadelphia experiments before the king and court in Paris and all the curious in the city flocked to see them.[21]

Professor Ludolf and Mr. Mylius conducted the experiments in Berlin by using a pointed iron rod 12 feet long which was raised on a 50-foot pole and connected to a summer house through a long iron wire. When a thunderstorm approached great sparks appeared which sometimes could produce shocks through the body as violent as those obtained from Leyden jars.[22] Similar experiments also were made at Florence, Bologna, and other places on the continent of Europe.

In October 1752 Franklin wrote to his friend Peter Collinson as follows:

"As frequent mention is made in the public papers from Europe of the success of the Philadelphia experiment from drawing electric fire from the clouds by means of pointed rods of iron erected on high buildings, and so forth, it may be agreeable to the curious to be informed that the same experiment has succeeded in Philadelphia, though made in a different and more easy manner which anyone may try as follows: Make a small cross of two light strips of cedar; the arms so long as to reach to the four corners of a large thin silk handerchief when extended. Tie the corners of this to the extremities of the cross, so you have the body of the kite; which being properly accommodated with a tail, loop, and string, will rise in the air like those made of paper; but this being a silk is fitter to bear wet and wind of a thunderstorm without tearing. To the top of the upright stick of the cross is to be fixed a very sharp pointed wire rising a foot or more above the wood. To the end of the twine next to the hand is to be tied a silk ribbon; and where the twine and silk join a key may be fastened.

"The kite is to be raised when a thunder gust appears to be coming on and the person who holds the string must stand within a door or window, or under some cover so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window.

"As soon as any of the thunder clouds come over the kite, the pointed wire will draw the electric fire from them and the kite, with all the twine will be electrified; and the loose filaments of the twine will stand out every way and be attracted by an approaching finger.

"When the rain has wet the kite and twine, so that it can conduct the electric fire freely, you will find it will stream out plentifully from the key on the approach of your knuckle. At this key a phial may be charged; and from the electric fire thus obtained spirits may be kindled and all other electrical experiments be performed which are usually done by the help of a rubbed glass globe or tube and I think that the sameness of the electric matter and that of lightning has been completely demonstrated.

"I was pleased to hear of the success of my experiments in France, and that they have begun to erect points on their buildings. We have placed them on our academy and Statehouse spires."[23]

In view of the tremendous havoc wrought by lightning, it may seem surprising that only one case of serious accident to any of those engaged in these experiments has been recorded. George William Richman, professor of experimental philosophy and member of the Imperial Academy of Science in St. Petersburg, became interested in the study of lightning and repeated Franklin's Philadelphia experiment. He constructed a new form of electroscope which was provided with a graduated scale called a "demonstrator of electricity." He then erected several long iron bars on the roof of his house and connected these by chains to the electroscope in his laboratory. With this arrangement he had been observing the state of the atmosphere and also the magnitude of the charge he was able to obtain from his static generator. Upon the approach of a thunderstorm in the summer of 1753, he brought a friend to his laboratory to show him the way in which his instrument would indicate the presence of electricity during a storm. When they entered the room the electroscope registered 4 degrees, which the professor said meant that the storm was at a distance, but he said that if the indicator should rise to 45 degrees or more, it would represent a truly dangerous condition. As he stood near the instrument a stroke of lightning, which was said to be of unusual intensity, hit the circuit. Professor Richman was killed instantly, his friend was stunned, and much woodwork in the house in the path of the lightning was shattered as the stroke went to the ground.[24]

Possibly it was by mere good fortune that no direct lightning strokes occurred during any of the other experiments that have been mentioned. On the other hand, Franklin himself met with an accident while conducting quite a different kind of experiment which might have ended his career. He gave the following account:

"I have lately made an experiment in electricity that I desire never to repeat. Two nights ago, being about to kill a turkey by the shock from two glass jars, containing as much electrical fire as 40 common phials, I inadvertently took the whole through my arms and body, by receiving the fire from the united top wires with one hand while the other held a chain connecting with the outsides of both jars. The company present say, that the flash was very great and the crack as loud as a pistol; yet, my senses being instantly gone, I neither saw the one or heard the other; nor did I feel the stroke on my hand, though I afterwards found it raised a round swelling where the fire entered, as big as half a pistol bullet; by which you may judge of the quickness of the electric fire, which by this instance seems to be greater than that of sound, light, or animal sensation. . . . . You may communicate this to Mr. Bowdoin, as a caution to him, but do not make it more public for I am ashamed to have been guilty of so notorious a blunder; a match for that of the Irishman, whom my sister told me of, who, to divert his wife poured the bottle of gunpowder on a live coal; or of that other, who, being about to steal powder, made a hole in the cask with a hot iron."[25]

Toward the close of the year 1752, after various reports had been received from many parts of Europe in confirmation of Franklin's theory of lightning, it was noted that no experiments of this character were being reported from England. William Watson offered the following explanation to the Royal Society:

"After the communications which we have received from several of our correspondents in different parts of the continent acquainting us with the success of their experiments last summer in endeavor to extract the electric power from the atmosphere during a thunderstorm in consequence of Mr. Franklin's hypothesis, it may be thought extraordinary that no accounts have been laid before you of our success here from the same experiments. That no want of attention therefore may be attributed to those here, who have been hitherto conversant in those inquiries, I thought proper to appraise you, that though several members of the Royal Society as well as myself, did upon the first advices from France prepare and set up the necessary apparatus for this purpose, we were defeated in our expectations from the uncommon coolness and dampness of the air here during the whole summer. We had only one thunderstorm in London and then the thunder was accompanied with rain, so that by wetting the apparatus the electricity was dissipated too soon to be perceived upon touching those parts of the apparatus which served to conduct it. This I say in general prevented us from verifying Mr. Franklin's hypothesis."[26]

Experiments with electric kites continued to be made well into the 19th century. In 1834 William Sturgeon, who was celebrated for his discovery of the electromagnet, thought that sufficient interest was being shown in this subject to make it desirable for him to write a paper cautioning the public against the improper use of the electric kite. The following extracts have been taken from this paper:

"Last Friday in the afternoon clouds began to form in various quarters of the heavens in rapid succession with every appearance of being highly electrical. I repaired to the Artillery grounds with an electrical kite and in a short time got it afloat, letting out string through the hand from a coil that was thrown on the ground. When about 100 yards of the string had been let out, a tremendous discharge took place, which gave me such a blow in the chest and legs that I became completely stunned, let go the string and consequently the kite soon fell.

"The accident was owing entirely to my neglect and it could not possibly have happened had I taken the following precaution. Let all the string intended to be employed be first taken off the coil and stretched on the ground. Let now the insulating cord, glass or whatever is used for the purpose, be attached to the kite string and fastened to a peg in the ground. Next fasten the kite to the other end of the string and let it ascend from the hand.

"I find it convenient to have a sliding copper wire on the silken cord which can be moved by means of a long glass rod to any required distance from the main wired string, the other end being stuck in the ground. If the electric fire strikes two inches over the dry silken cord (and it will sometimes strike a yard), it would not be safe to approach it and no man could hold the string when it strikes over one inch.

"The only method of getting the kite down during a storm with safety is to unfasten the silken cord from its hold and let all go so that the kite falls."[27]

The afore-mentioned main wired string evidently means that a special kite string had been devised which utilized a fine wire central core to increase its conductivity.

William Sturgeon also gave a vivid account of the results that might be obtained through the ingenious experiment that had been devised by Franklin:

"On June 14th, at about eight o'clock in the evening, an electric storm passed over this place exhibiting lightning the most splendid ever beheld. The rain fell so heavily that it was with some difficulty that I got the kite afloat; and when up its greatest altitude, I imagine, did not exceed 50 yards. The silken cord also, which had been intended for the insulation, soon became so completely wet that it was no insulator at all. Notwithstanding all these impediments being in the way, I was much gratified with the display of the electric matter issuing from the end of the string to the wire, one end of which was laid on the ground, and the other attached to the silk at about four inches distance from the reel of the kite string. An uninterrupted play of fluid was seen over four inches of wet silken cord, not in sparks, but in a bundle of quivering purple ramifications, producing a noise similar to that produced by springing a watchman's rattle. Very long sparks, however, were frequently seen between the lower end of the wire (which rested on the grass) and the ground; several parts of the string towards the kite, where the wire was broken, were occasionally beautifully illuminated. The noise from the string in the air was like to the hissing of an immense flock of geese, with an occasional rattling or scraping sort of noise.

"Two noncommissioned officers of the Royal Artillery were standing by me the whole time and would gladly have approached close to the string had not I convinced them of the danger of touching or even coming near the string during the storm. We anxiously watched what was going on at the other end of the string and the display was beautiful beyond description. The reel was occasionally enveloped in a blaze of purple arborized electric fire, whose numberless branches ramified over the silken cord and through the air to the blades of grass which also became luminous on their points and edges, over a surface of some yards in circumference. We also saw a complete globe of fire pass over the silken cord which appeared to be about the size of a musket ball and which was exceedingly brilliant."[28]

The following account of electric kite experiments made by a local scientist in the north of England appeared in the *Lancaster Gazette* for April 5, 1834:

"On March 29th, I had a favorable opportunity of demonstrating experimentally to several of my friends at Kirkby Lonsdale, who had attended my recent course of lectures at that place, that an abundance of the electric fluid usually attends hail and snowstorms. During three hailstorms I floated one of my silken electric kites, with a wired string about 300 yards long, and insulated at its base in the usual way by means of a silken cord.

"The kite was elevated in each case about ten minutes prior to the arrival of the storm and the state of the atmosphere was ascertained and was found to be so feeble that not the slightest spark could be observed. As, however, the cloud from which hail was falling approached the kite, the fluid from the string presented itself in brilliant sparks to the knuckle; and during the transit of the cloud, became so abundantly discharged to the wire that was presented to the string that it struck in rapid succession through a stratum of six inches of air, and through three inches of air it presented a splendid continuous stream of electric fire.

"These appearances were exhibited in each experiment, but the display of the electric fire was the most magnificent in the second, which was during the fiercest hailstorm of that day. During an early part of this storm the electric fluid made a continuous rattling noise down the kite string (in consequence of the wire being broken in several places), and darted from the reel at the inferior extremity, to greater distances than in the other experiments. In one instance it struck over a stick about a yard long, to the hand of a young man who was presenting it to the kite string. Although the remote end of the stick was in contact with the ground by means of a very wet string and consequently a considerable discharge must have passed down the wet string to earth, yet the shock was so violent as to make the young man reel and nearly fall."[29]

As has been noted the first lightning rods were installed in 1752. One of the first installations in the United States was on the tower of the Statehouse, later known as Independence Hall, in Philadelphia. Franklin tried to stimulate the introduction of his method of lightning protection by citing cases of serious lightning damage to structures which might have been avoided by the use of lightning rods. In 1749 Captain John Waddell reported to the Royal Society that his ship *Dover*, newly launched, on a voyage from New York to London had encountered a very heavy storm in which electrical discharges resembling great torches appeared at the mastheads followed by a severe lightning stroke. Lightning shattered the main mast, disabled many of the crew, and caused so much damage to the body of the ship that it began to leak. The *Dover* had great difficulty in reaching land, accentuated by the fact that the four compasses of the ship were demagnetized.[30]

Franklin then sent a communication to the Royal Society showing how wire connections between the mastheads and the sea would have protected the ship and possibly would have prevented the stroke entirely. He also took that occasion to describe some interesting experiments that he had made in which he had magnetized steel needles by electrical means.[31]

Many reports of severe damage from lightning were being discussed in the technical press of that day and Franklin contributed several of these. The following case was one of the most significant:

> "Being in the town of Newbery in New England I was shown the effect of lightning on their church which had been struck a few months before.
>
> "The steeple was a square tower of wood reaching 75 feet up from the ground to the place where the bell hung, over which rose a taper spire, of wood likewise, reaching 75 feet higher to the vane of weathercock. Near the bell was fixed an iron hammer to strike the hours; and from the tail of the hammer a wire went down through a small gimlet hole in the floor that the bell stood upon, and through a second floor in like manner; then horizontally under and near a plastered ceiling of that second floor, till it came near a plastered wall; then down by the side of that wall to a clock, which stood about 20 feet below the bell. The wire was not bigger than a common knitting needle.
>
> "The spire was split all to pieces by lightning and the parts flung in all directions over the square in which the church stood, so that nothing remained above the bell. The lightning passed between the hammer and the clock on the above-mentioned wire without hurting either of the floors or having any effect upon them except making the gimlet holes a little bigger, and without hurting the plastered wall, or any part of the building so far as the aforesaid wire and pendulum wire of the clock extended; which latter wire was about the size of a goose quill. From the end of the pendulum down quite to the ground the building was exceeding rent and damaged and some of the stones in the foundation wall torn out and thrown to the distance of 20 or 30 feet. No part of the afore-mentioned long small wire between the clock and the hammer could be found except about two inches that hung to the tail of the hammer and about as much that was fastened to the clock; the rest being exploded and its particles dissipated in smoke and air as gunpowder is by common fire, and had only left a black smutty track on the plastering three or four inches broad, darkest in the middle and fainter towards the edges. All along the ceiling under which it passed and down the wall. These were effects and appearances on which I would only make a few remarks; namely:
>
> 1. That lightning in its passage through a building will leave wood to pass as far as it can in metal, and not enter the wood again till the conductor of metal ceases. And the same I have observed in other instances as to walls of brick and stone.
>
> 2. The quantity of lightning that passed through this steeple must have been very great by its effects on the lofty spire above the bell and on the square tower all below the end of the clock pendulum.
>
> 3. Great as the quantity was, it was conducted by a small wire and clock pendulum without the least damage to the building so far as they extended.
>
> 4. The pendulum rod being of sufficient thickness conducted the lightning without damage to itself; but the small wire was totally destroyed.
>
> 5. Though the small wire was itself destroyed yet it had conducted the lightning with safety to the building.
>
> 6. From the whole it seems probable that if even a small wire had been extended from the spindle of the vane to earth, before the storm, no damage would have been done to the steeple by that stroke of lightning though the wire itself had been destroyed."[32]

Franklin's activity in advising the adoption of his invention for the protection of property yielded rich results, and his lightning rods soon came into general use. In 1753 he received the Copley medal from the Royal Society of London for his scientific achievements and a little later was made an honorary member of the society by unanimous vote. At about the same time he also became a member of the Royal Academy of Science of Paris and within a few years was admitted to practically all of the learned societies of Europe. His Philadelphia friend, Ebenezer Kinnersley, who it will be recalled was started by Franklin on his scientific career, wrote a long letter to Franklin in 1763 which was read before the Royal Society and in which he described many of his experiments, closing with this eulogy:

> "And now, Sir, I most heartily congratulate you on the pleasure you must have in finding your great and well-grounded expectations so far fulfilled. May this method of security from the destructive violence of one of the most awful powers of nature meet with such success, as to induce every good and grateful heart to bless God for this important discovery. May the benefit thereof be diffused over the whole globe. May it extend to the latest posterity of mankind; and make the name of Franklin, like that of Newton immortal."[33]

Franklin continued to correspond with his scientific friends regarding electrical matters, but from 1754, when he was appointed a delegate from Pennsylvania to the first General Assembly of all the Colonies, up until his death in 1790, he was unable to do any experimental work of his own as he was absorbed completely in his career as statesman, diplomat, and philanthropist.

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Turbine-Electric Coast Guard Cutters

WITH THE COMPLETION of its present construction program the United States Coast Guard will maintain a fleet of 13 turbine-electric a-c vessels having complete automatic control from the pilot house. They also are provided with either automatic or manual control from the engine room. Propulsion motors and generators are of minimum size because the use of regulated stability and automatic synchronizing permits the machines to be designed with very little inherent torque margin. Most of the vital propulsion auxiliaries are driven by motors taking power from a transformer connected to the propulsion bus and operate at from 90 to 15 cycles with facilities for transfer to a 60-cycle bus.

Each ship is equipped with one propulsion generator which supplies power to one synchronous propulsion motor. Speed control of the motor is obtained by adjusting the speed of the turbine driving the propulsion generator. The propulsion turbine is of the single-flow complete-expansion combined impulse and reaction type.

The accompanying figures illustrate equipment aboard the United States Coast Guard cutter *Mendota*.

Essential substance of an article by J. A. Wasmund, marine engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.

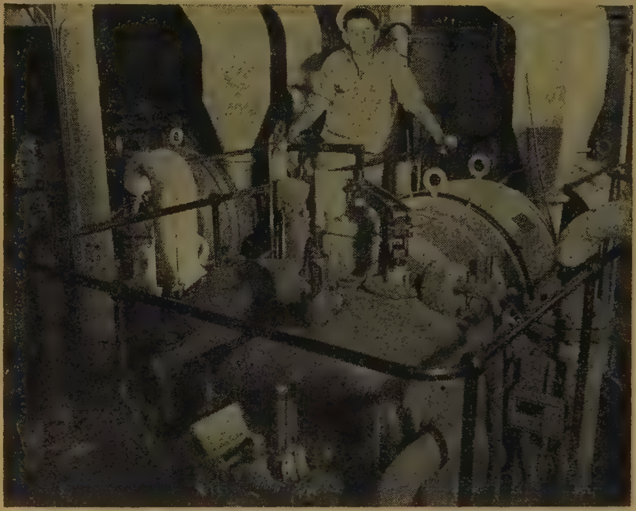
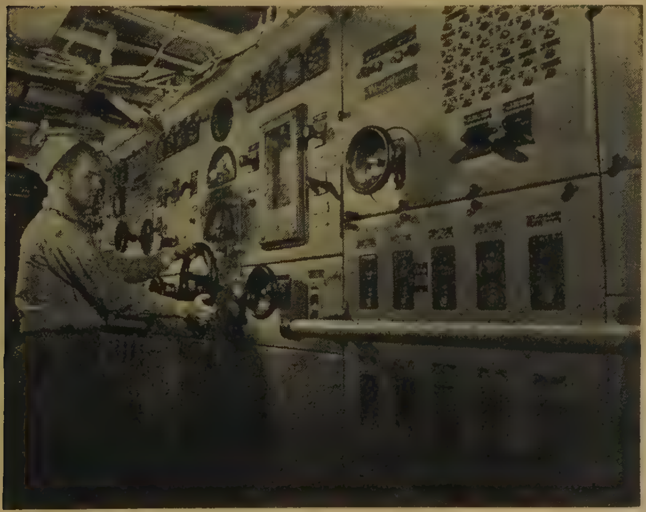
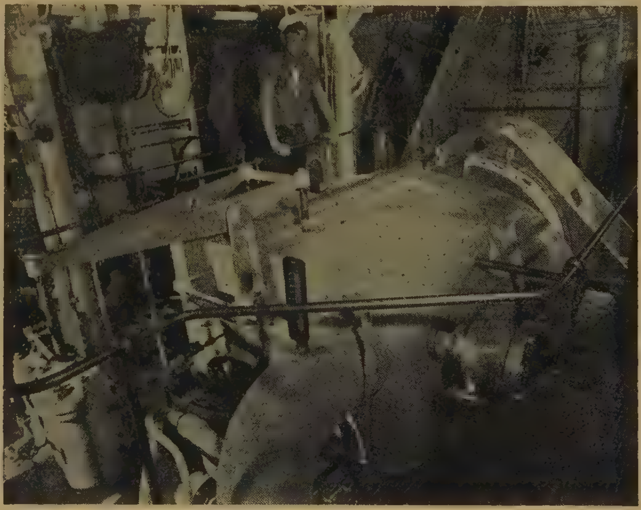


Figure 1 (above). Auxiliary turbine generator sets

Figure 2 (below, left). Propulsion control and auxiliary switchboards

Figure 3 (below). Propulsion turbine generator set





Electric Measuring Instruments

D. M. NIELSEN

During recent years the influence of electronics on process measurement and control instruments has been evidenced by a great increase in electric measuring instruments. The author of this article analyzes the characteristics of these new instruments in general and, by way of illustration, describes several specific products and their operation. Comparisons of electronic instruments with the corresponding mechanical types indicate the prospective applications for each.

THE PURPOSE of this article is to present a brief survey of new electric instruments for measuring process variables such as temperature, pressure, flow, and hydrogen-ion concentration. In this respect it has three major aims:

1. To cover recent developments by the process instrument companies in electrical types of recording and controlling instruments, with emphasis on new electronic instruments.
2. To point out the way in which the application fields of electric equipment companies and the process instrument companies are beginning to overlap.
3. To point out the impact of electronics on process measurement and control instruments.

One possible approach to this general subject of new developments and trends in instruments is to consider separately the various functional elements in recording and controlling instruments, especially the use of electronic techniques in each.

Functionally, an instrument may be broken down conveniently into the various units shown in Figure 1.

Electronic units possibly could be used as sensitive elements, as part or all of a recording mechanism, as a controller mechanism, and as a final control element. Instruments or control equipment using electronic tubes and circuits in each of these functional ways are on the market.

However, before investigating these various uses of electronics some background information on the characteristics of vacuum tubes as used in instruments is desirable.

CHARACTERISTICS OF VACUUM TUBES FOR INSTRUMENT USE

Vacuum tubes commonly are employed in rectifiers, control switches, amplifiers, and oscillators but in industrial equipment there is strong competition from other electric devices which already have been in use commercially and which have given satisfactory operation. Copper oxide and selenium oxide rectifiers, for example, have been utilized widely in instruments for many applications. The number and types of mechanical relays and switches available today are extremely great. Recording and indicating null-balance electric instruments for some years have used electromechanical amplifiers in galvanometer and chopper-type balancing systems. In laboratory bridges, the use of tuning fork audio-frequency generators long has been common.

Some of the characteristics of vacuum tubes which are especially useful in instrument applications are the following:

1. High input impedance.
2. High amplification.
3. Sturdiness and comparative immunity to vibration.
4. High speed action.
5. Mechanical simplicity.
6. Absence of moving parts.
7. Versatility.
8. Low cost.
9. Inherent load-limiting characteristics.

Other characteristics of vacuum tubes limit their use in instruments. These characteristics include:

1. Variation in tube characteristics.
2. Nonlinearity of tube parameters.
3. Effect of changes of *A*, *B*, and *C* battery voltages and grid and plate circuit elements on tube characteristics.
4. Change in filament emission characteristics with age and service life.
5. Low power efficiency.
6. Ambient temperature effects.
7. Limited tube life.

The following discussion considers the characteristics of vacuum tubes, especially as they apply to use in the various functional parts of instrument systems (sensitive elements, measuring mechanisms, controlling mechanisms, and so forth).

SENSITIVE ELEMENTS FOR ELECTRIC INSTRUMENTS

Electric sensitive elements are conversion units in which a change of a physical variable, for example, temperature, radiant energy, pressure, flow, pH, solution conductivity, strain, or gas composition produces a change of some electrical variable such as voltage, current, resistance, capacitance, or inductance.

The outputs of the various types of sensitive elements for process application are often at very low levels and

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they have other characteristics which make instrumentation difficult.

Table I lists some of the generally used electric sensitive elements for process measurements, classified by the physical variable measured, and includes typical output level and element impedance data.

Table II gives additional applications of the same elements in process applications where the basic sensitive element is combined with another responsive element. This may be illustrated by the combination of a strain gauge with an elastic tube for fluid pressure measurement. These two tables include almost every variable encountered in process work.

Of all the electric sensitive elements listed in these tables only three are electronic in nature. Very probably this is to be expected from the very purpose of a sensitive element. Considering that the action of electronic tubes is based on controlling the flow of streams of electrons or ions between electrodes in an evacuated or a gas-filled enclosure, the problem of designing electronic sensitive elements then becomes one of influencing this electron or ion current by means of the variable which is to be measured.

Little has been done so far on commercial development of such units except for a few specialized electronic sensitive elements for process measurements briefly described later. It is pertinent at this point to discuss several widely used electric sensitive elements to see how instrument design has been influenced by either their conversion characteristics or by other problems accompanying their use.

Briefly, and inaccurately, the glass electrode is a sensitive element which produces a direct voltage proportional to the pH (or hydrogen ion concentration) of an aqueous solution in which it is immersed.

The direct-potential difference produced may be as great as about 0.8 volt so it would seem simple to measure until it is considered that the glass membrane of the electrode is by general engineering standards an excellent insulator and that the ion current through the glass, which causes the output voltage, is extremely small. If the measuring circuit draws off electrons faster than the flow of ions through the glass can restore them, the potential difference balance is upset and measuring errors result. The internal resistance of various types of glass electrodes is from 6 to 500 megohms and commonly is greater than 50 megohms. For a typical electrode the current from the electrode during continuous measurement must not exceed 10^{-11} amperes.

This characteristic limits greatly the types of measuring equipment which can be used with glass electrodes. The instruments now used are electronic types, usually d-c amplifiers. The output circuits of these amplifiers supply enough power to operate a moving-coil d-c milliammeter or else a potentiometer recorder.

Wire resistance strain gauges are primary elements for measuring small linear changes of dimension of the surfaces to which they are attached. Surface strain causes a proportional percentage change of electrical resistance of the gauge, which is measured with a suitable instrument.

The major problem in strain gauge instrument design is that of measuring accurately the very small changes in gauge resistance resulting from applied strain. For example, it is desired to record accurately strains causing a resistance change of 0.0024 ohm in a gauge having a resistance of approximately 120 ohms.

A second major problem is the development of suitable null-balance indicators for manually operated bridges and automatic balancing mechanisms for recorders. For the measuring accuracy required, the instrument balancing system must take positive action on unbalance voltages of less than 15 microvolts.

Table I. Electric Sensitive Elements for Process Applications

Physical Variable	Sensitive Element		Measuring Circuit	Typical Operating Conditions		
	Type	Electrical Variable		Instrument Range	Output Range*	Element Impedance (Ohms)**
Temperature	Thermocouple	D-c electromotive force	Potentiometer	0–1,200 degrees Fahrenheit	0–32 millivolt	10–50
	Resistance bulb	Resistance change	Bridge	0–100 degrees Fahrenheit	0–5 per cent unbalance	25–200
Radiant energy	Vacuum thermocouple	D-c electromotive force	Potentiometer		0–1 millivolt	<100
	Bolometer	Resistance change	Bridge		0–1 per cent unbalance	35
	Photoelectric cell (Cs+Ag)	Electron current	Potentiometer			$>10^6$
	Thermopile	D-c electromotive force			0–3 millivolt	25–100
Strain	Wire gauge	Resistance change	Bridge	0.001 inch per inch	0–0.2 per cent unbalance	120–150
	Inductive gauge	Inductance change	Bridge	0.001inch per inch	0–20 per cent unbalance	<100
	Capacity gauge	Capacitance change	Bridge or special	0.001 inch per inch	0–20 per cent unbalance	$>10^5$
	Piezo crystal	D-c electromotive force	Potentiometer or oscilloscope	0.001 inch per inch	0–1.0 volt	
Pressure	Pirani gauge	Resistance change	Bridge	0.1–10 microns		100
	Ionization gauge	Direct current	Special vacuum tube	10^{-3}–10^{-9} millimeters Hg		5,000
Miscellaneous						
pH	Glass electrode	D-c electromotive force	Potentiometer	0–7.0 pH	0–0.4 volt	$(6–500) \times 10^6$
Solution strength	Conductivity cell	Resistance change	Bridge	0–30 micromhos	0–1,300 per cent	3,300–50,000
Gas analysis	Thermal conductivity cell	Resistance change	Bridge	0–20 per cent CO_2	0–0.2 per cent unbalance	50
Polarography	Dropping Hg electrode	D-c electromotive force			0–3 volt	

* Bridge circuits assume that all arms equal resistance when sensitive element resistance at lowest value. ** Including leads.

Table II. Applications of Sensitive Elements Combined With Other Responsive Elements

Primary Variable Measured	Secondary Variable	Means of Measurement
Temperature difference	Humidity (relative)	Wet and dry bulb
Temperature	Humidity (absolute)	Hygroscopic equilibrium element
Radiant energy	Mass spectrometer Absorption spectrometer	
Strain	Fluid pressure Fluid pressure difference Fluid flow rate Fluid liquid level Weight Dimension gauging Force Torque	
Radiation	Colorimetric analysis Turbidity	
Capacitance	Moisture	Hygroscopic dielectric in moisture balance with unknown material
	Thickness	Nonhygroscopic material as dielectric
Inductance	Thickness	Magnetic materials
Resistance	Moisture Thickness	Hygroscopic material

The answer to these problems was the design of instruments using electronic balancing units.

Thermocouples are too well known as sensitive elements for the measurement of temperature to need description.

Today there is a strong trend toward the general use of electronic self-balancing recording potentiometers because of the various industrial application problems plus the limitations of mechanical instruments rather than by the electrical characteristics of thermocouples.

Factors contributing to this trend include the following:

1. Modern continuous unit processes, notably in the chemical and petroleum refining industries, have required narrower measuring ranges to obtain greater sensitivity and better automatic control.

2. Rebalancing speed of mechanical recorders necessarily is slow because of the response characteristics of the galvanometer and the intermittent balancing cycle.

3. The general tendency of galvanometers toward unstable and erratic action under severe vibration conditions is a handicap.

4. Mechanical balancing systems, though highly perfected, do require periodic maintenance and skilled adjustment to operate properly, as in the case of any fine machine.

ELECTRONIC SENSITIVE ELEMENTS

Electronic sensitive elements may be divided into two general classes: photoelectric cells in which the electron stream is varied by radiant energy passing through the transparent wall and gas pressure or analysis tubes which depend on passing a continuous sample of gas vapor through the tube and which measure resulting variations in ion current.

Photoelectric cells are special vacuum tubes used as sensitive elements with electric instruments for the detection or measurement of radiant energy. They are used primarily in electric optical instruments such as spectrophotometers, color comparators, and photometers.

The ionization gauge measures very low absolute pressures over the range of 0.1–200 microns. It uses a special three-element (filament, grid, and plate) vacuum tube whose envelope is connected to the vacuum system so that the system pressure exists in the tube. The gas in the tube is ionized by collision and the ion current to the plate is proportional to the number of gas molecules present, or to the gas pressure in the tube. The plate current meter is calibrated in terms of gas pressure in microns.

The mass spectrometer analyzes a stream of gas by separating it into beams of molecules according to mass while recording the presence and relative percentage of each beam.

The heart of this instrument is a special electronic analysis tube. The gas stream is introduced into the tube at a constant rate and passes through a high velocity electron beam which ionizes gas molecules by collision. The stream of gas ions is formed into a beam by suitable electrostatic focusing and accelerating electrodes. The path of these ions then is bent by a magnetic field and the ions pass into a curved part of the tube at the end of which is a collecting electrode. If the magnetic field is weak, only the ions with small mass will be deflected sufficiently to hit the collecting electrode. If the magnetic field is increased gradually, ions with successively greater mass will hit the collecting electrode. The ion current at the collecting electrode and through the external circuit will be proportional to the number of the ions of one particular mass striking the electrode at the time. Thus, if the relation between the strength of the magnetic field and the mass of the ions which will strike the electrode is known, then a curve of the collecting electrode current against the ion mass can be plotted to show the percentage composition of the original gas sample classified by mass of the molecules present.

ELECTRONIC MEASURING INSTRUMENTS

Electronic process instruments measure the output of electric sensitive elements. That is, they measure one of the electrical variables; voltage, current, resistance, inductance, or capacitance.

For purposes of analysis, null-balance measuring instruments can be considered as made up of various functional units:

1. Measuring circuit, where the magnitude of an unknown variable is measured by comparison with an adjustable standard.

2. Null-balance electromechanical or electronic unit which detects unbalance between magnitudes of unknown and adjustable standard, amplifies this difference, and through a power motor readjusts standard to obtain an exact balance in the measuring circuit, and simultaneously drives the indicating or recording mechanism.

3. Indicating or recording mechanism, a pointer and scale or pen and chart which converts position of slide wire contact or

other type of adjustable standard into a direct reading of the unknown variable.

The measuring circuits in electronic instruments are the same type as those used in mechanical instruments and in laboratory equipment. Potentiometers measure voltage and current. Bridges are used to measure resistance, inductance, and capacitance.

The elements in these circuits are fixed and adjustable resistors, capacitors, or inductors which are highly stable under varying conditions of temperature and humidity and also age. In comparison, the resistance and capacitance properties of vacuum tubes are affected greatly by such conditions of operation as grid filament and plate voltages, ambient temperatures, service history of tube, and so forth. The various operating characteristics of vacuum tubes are so interrelated and so limited in value practically by construction requirements and other factors that the design of commercial tubes to produce desired values of resistance or capacitance over the range of values necessary for measuring circuit use is now impractical.

On adjustable standards much the same comparison as for fixed elements holds. In addition, there is the vital difference for instrument use that the end product of the instrument is the motion of an indicating pointer or a recording pen which usually is connected mechanically to a slide wire contact or a capacitor rotor. Someplace in the instrument there must be this electromechanical link. The vacuum tube is not designed as yet for this type of application and so, altogether, it now has no place in instrument measuring circuits as a resistance, capacitance, or inductance element. On the other hand, vacuum tubes have been used very successfully in oscillator circuits for a-c power supplies for bridges.

Vacuum tubes also have been used widely in balance indicators in manually operated instruments and in automatic balancing systems for recorders. In these applications they perform a power relay or a servomechanism function. That is, they replace a galvanometer balance detector and an intermittently operating clutch and feeler slide wire contact drive mechanism. In practically every case, the number of moving parts in the instrument is reduced greatly and, as the tubes are not in the measuring circuit, their performance variations affect balancing speed and limiting sensitivity primarily and measuring accuracy only to a minor extent. And it is simple to design with ample safety factors for these effects.

To point out briefly various features of the electronic servomechanisms now being used in automatic balancing systems, various commercial recording instruments on the market at present will be described.*

The "Brown Electronik D-C Potentiometer Recorder" is shown in Figure 2. A conventional slide wire potentiometer circuit is used in this instrument. The slide wire contact is connected mechanically to the recording pen and pointer and the balancing drive motor through a cable system and gears.

The d-c unbalance voltage from the potentiometer is converted into an alternating voltage before amplifying. The d-c–a-c conversion unit includes a synchronous vibrator switch and a coupling transformer. The vibrator is a magnetically polarized metal reed which is fixed at one end while the other end is free to vibrate. A solenoid coil is mounted near the free end of the reed. This coil, which is energized from the a-c power supply source, alternately attracts and repels the polarized metal reed at power frequency. The reed carries moving contacts and oscillates back and forth between two fixed contacts. The vibrator thus acts as a single-pole double-throw switch. As shown in the wiring diagram, it is connected into the unbalance circuit in series with the coupling transformer so that it reverses connections from the unbalance circuit to the primary winding of the coupling transformer 60 times a second (or whatever the line frequency is) and so reverses the direction of flow of the d-c unbalance current in the transformer primary winding.

This reversing direct current in the primary winding induces in the transformer secondary winding an alternating voltage which is approximately proportional to the unbalance voltage. The alternating voltage also reverses in phase as the slide wire contact passes through null balance point. This voltage is amplified by a conventional three-stage a-c amplifier to control the balancing drive motor, a two-phase a-c induction motor. The operation of this depends on the production of a rotating magnetic field by having the alternating currents in the two windings 90 degrees out of phase. If the "control" winding current leads the "power" winding current by 90 degrees, the motor runs one way. If the "control" winding current lags the "power" winding current by 90 degrees the motor runs the other way.

The current through the "control" winding is controlled by two power amplifier tubes connected so that

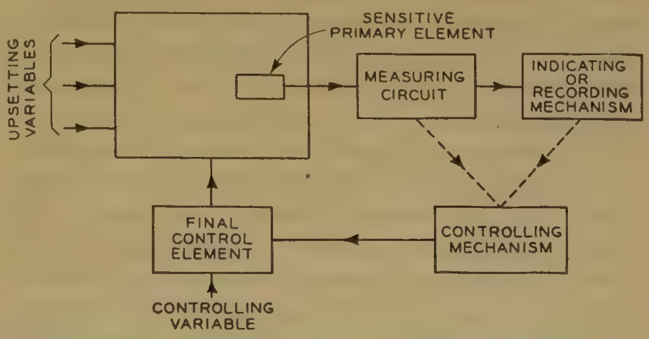

Figure 1. Block diagram of electrical process measurement and control system

the plate currents of both tubes flow through the winding. The amplified a-c unbalance voltage is applied to the grids of both these tubes and controls the amount of plate current flowing. The plate circuits of these tubes are supplied separately with alternating voltages by two power transformer windings connected so that one plate is positive when the other is negative. As these tubes pass plate current only when their plates are at positive potentials, and this condition occurs alternately in the two tubes, only one tube can pass current at any one time.

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* No mention is made of the instruments built by Bailey Meter Company because no published information was available at the time this article was prepared. These instruments have been described in detail in a paper presented before the Industrial Instruments and Regulators Division of American Society of Mechanical Engineers at the 1944 Annual Meeting.

If the potentiometer circuit is unbalanced, the amplified a-c unbalance voltage is applied to the grids of both power amplifier tubes. As this same voltage is applied to the grids of both tubes and the plates of these tubes are supplied with oppositely phased alternating current, this unbalance voltage will be in phase with the plate voltage on one tube and 180 degrees out of phase with the plate voltage on the other tube. In the tube in which grid and plate voltages are in phase (that is, both are positive at the same time), the plate current will increase and in the other tube (in which the grid is negative when the plate is positive), the plate current will decrease. The resultant "control" winding current thus becomes an alternating current, which will be either in phase with the power supply or else 180 degrees out of phase with it, depending on which tube is passing the greater current.

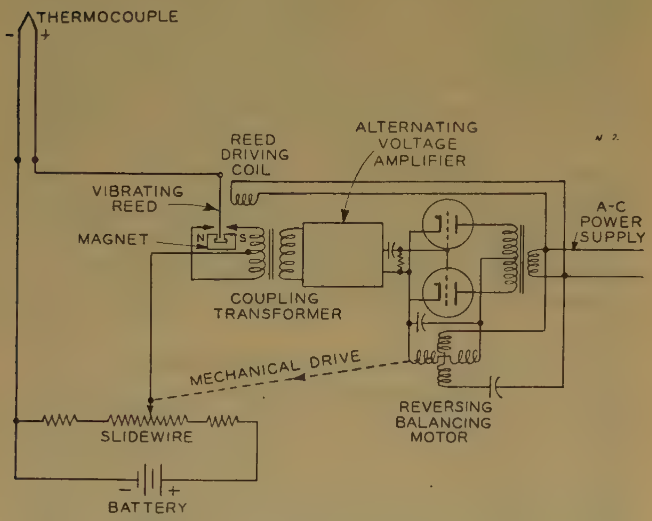


Figure 2. Brown "Electronik" self-balancing potentiometer

A capacitor is connected in series with the "power" winding on the motor so that the current in this winding is 90 degrees out of phase with the power supply. Whenever the potentiometer is unbalanced, the current in the "control" winding either will lead or lag the current in the "power" winding by 90 degrees, depending on which power amplifier tube is passing the greater current. The control as to which tube passes the greater current thus depends on the phase of the amplified a-c unbalance voltage, which in turn is determined by whether the potentiometer slide wire contact is above or below balance. In this way the balancing motor rotates in the proper direction to drive the slide contact back to the balance point and to drive the recording pen and indicating pointer.

The magnitude of the alternating current in the control winding is approximately proportional to the d-c potentiometer unbalance voltage. This in itself means fairly good balancing action because the motor power and speed decrease as the slide wire contact approaches the balance point. It also means that the motor has low torque for small unbalance conditions, which is undesirable. This difficulty is avoided practically by using high amplification of the unbalance voltage so that the motor develops a high torque on small changes.

The "control" winding has a pulsating direct current flowing through it at the balance point. The capacitor connected across this winding smooths out the pulsating current to give a steady direct current which, flowing through the control winding, applies a braking effect to the motor.

Figure 3 illustrates a Leeds and Northrup "Speedomax Electronic D-C Potentiometer Recorder" in which a conventional slide wire potentiometer circuit is used. The slide wire contact carries a recording pen carriage and is connected mechanically to the balancing drive motor through a cable system.

The d-c unbalance voltage from the potentiometer is converted into an alternating voltage before amplifying. The actual d-c–a-c conversion is made by a modulator and a coupling transformer. This modulator and the primary winding of the coupling transformer are connected in series in the unbalance circuit where a galvanometer would be situated in mechanical instruments. The modulator is a carbon microphone button driven magnetically by an exciting coil which is energized from the a-c power supply of the instrument. As the button diaphragm vibrates back and forth at power-line frequency, it changes the pressure on the carbon particles in the button which, in turn, changes the electrical resistance of the button. The variation of resistance in the modulator causes the d-c unbalance current flowing through this circuit to pulsate. The pulsating part of this direct current is in effect an alternating voltage that induces an alternating voltage at power supply frequency in the secondary winding which is connected to the input of a conventional vacuum tube amplifier. This voltage is approximately proportional in amplitude to the d-c unbalance voltage and reverses in phase as the potentiometer slide wire contact passes through the null balance point.

The balancing drive motor is a series d-c motor whose reversing action is provided by two separate field windings which are connected in the plate circuits of two thyratron tubes. These tubes are gas-filled triodes which act as grid controlled rectifiers to supply pulsating direct current to the motor fields.

The amplified a-c unbalance voltage is applied to the two thyratron tube grids through a transformer so that equal but opposite sign voltages are impressed on them. That is, one grid is negative when the other is positive and conversely the thyratron plate voltages are alternating current supplied by a transformer connected so that both plate circuits are positive at the same time. Because of this method of connection of grids and plates of the thyratrons, in one tube the grid voltage will be positive at the same time that the plate voltage is positive and this tube will pass direct current through its motor field winding. In the other tube, the grid will be negative when the plate is positive and a small or even zero current will flow in its motor winding.

The wiring connections are such that the amplified a-c unbalance voltages fire the proper thyratron to energize the correct series field winding in order for the motor to drive the slide wire contact back to balance. As previously mentioned, the a-c unbalance voltage reverses phase when the potentiometer goes through the balance point, the opposite thyratron then fires, and the slide wire contact is driven in the other direction.

The method used to prevent hunting is the connection of a d-c tachometer generator (mechanically driven by the balancing motor) in series with the modulator and coupling transformer in the potentiometer unbalance circuit. This generates a direct voltage with polarity determined by its direction of rotation and voltage magnitude determined by speed of rotation. This generator is connected so that its voltage bucks any potentiometer unbalance voltage.

With the balancing motor driving at a constant speed back to the potentiometer balance point, the tachometer voltage is constant and the unbalance voltage is decreasing. As soon as the tachometer voltage becomes greater than the unbalance voltage, the net voltage in the unbalance circuit reverses polarity. The resulting a-c unbalance voltage reverses phase and braking torque is applied to the balancing motor, which continues to rotate in the same direction but at a decreasing speed. As it slows down, the tachometer generator voltage falls. With both the tachometer and the unbalance voltages falling together, the instrument comes to balance smoothly and without overshoot.

In the Tagliabue "Celectray D-C Potentiometer Recorder" shown in Figure 4 a conventional slide wire potentiometer circuit is used. The slide wire contact carries a recording pen carriage, and is connected mechanically to the balancing drive motor. Potentiometer unbalance is detected and amplified by a combination of a mirror galvanometer, photoelectric cell, and an amplifier tube.

The galvanometer is connected in a conventional way in the slide wire contact circuit so that its coil will deflect in proportion to the amount of potentiometer unbalance and in a direction determined by whether the potentiometer slide wire contact is above or below the balance point. A light beam from a lamp source is reflected by the galvanometer mirror back past a controlling edge onto the sensitive surface of a photoelectric cell. The instrument optical system is adjusted so that the beam is cut off partly by the controlling edge when the potentiometer is balanced. If the slide wire contact is below the balance point, the galvanometer deflects so that all the light is cut off from the cell. If the contact is above the balance point, then the full light beam strikes the cell.

The photoelectric cell is connected between the grid and plate of the amplifier tube and in series with a resistor between the grid and the filament. This circuit is a voltage divider in which the resistance of the photoelectric cell is decreased when light falls on it. The voltage on the grid of the tube thus is determined by the amount of illumination on the photoelectric cell.

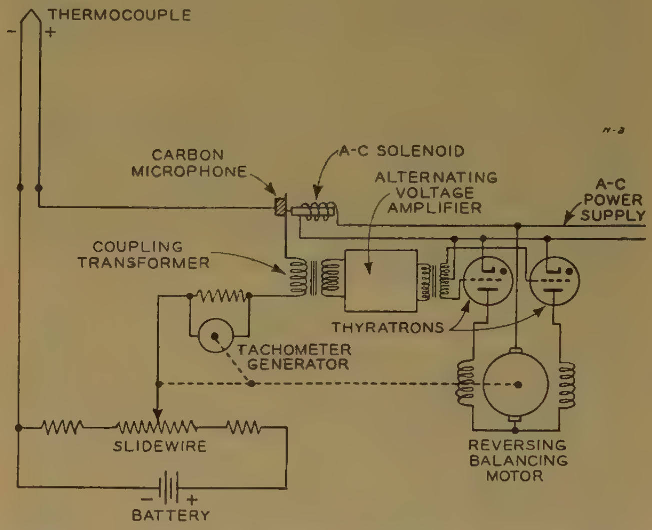


Figure 3. Leeds and Northrup Speedomax electronic self-balancing potentiometer

When the galvanometer deflects to increase the illumination on the photoelectric cell, more current will flow through it driving the grid of the vacuum tube more positive so that its plate current will increase. Conversely, when the galvanometer deflects in the opposite direction to decrease the illumination on the photoelectric cell, the amplifier tube plate current will decrease. These variations in amplifier tube plate current control the balancing drive motor through a pair of telephone-type relays.

The balancing drive motor is a split-phase induction motor with two similar windings, one of which is connected directly to the power supply while the other is connected through a capacitor. This makes the current in the two windings 90 degrees out of phase and the motor operates as a two-phase induction motor. The direction of the rotation of the motor is reversed by shifting the phasing capacitor from one winding to the other.

The wiring diagram in Figure 4 shows the control relays and their connections to the balancing drive motor. Relay 1 will close on a slightly lower current than relay 2.

The instrument is adjusted so that when the potentiometer is balanced relay 1 is closed and relay 2 is open. In this condition, the motor control contacts on both relays are open and the motor stands still.

The amplifier tube plate current increases when the slide wire contact is below the null-balance point which closes relay 2. This connects the left-hand motor winding directly to the line and the right-hand winding to the line through the capacitor. The balancing motor then rotates in a direction to drive the slide wire contact upscale until the potentiometer is balanced, when relay 2 opens.

If the slide wire contact is above the balance point, the amplifier tube plate current decreases and relay 1 opens. The right-hand motor coil now is connected directly to the line and the left coil through the capacitor. The motor now rotates in the opposite direction to drive the slide wire contact downscale until the potentiometer balance is restored.

The capacity-resistance net work in the grid circuit of the amplifier tube helps to prevent hunting by preventing sudden changes of illumination on the photoelectric cells from causing immediate and large changes in the amplifier tube plate current. Following any change of illumination, the grid voltage changes somewhat immediately and then drifts still further in the same direction until the final full change produced by the change of illumination on the photoelectric cell is reached.

A second antihunting means is the pair of "advancing electromotive force" contacts on the relays. When the slide wire contact is below the null-balance point, relay 2 is closed as described. The close of the "advancing electromotive force" contact on relay 2 lowers the potential of the reference point. The introduction of this extra voltage causes the galvanometer to reach the balance point and open relay 2 before the potentiometer circuit has reached the null position. The motor continues to coast after relay 2 opens, driving the contact towards true balance but there may be several short intermittent relay operations with resulting small boosting or braking actions before the contact does reach balance.

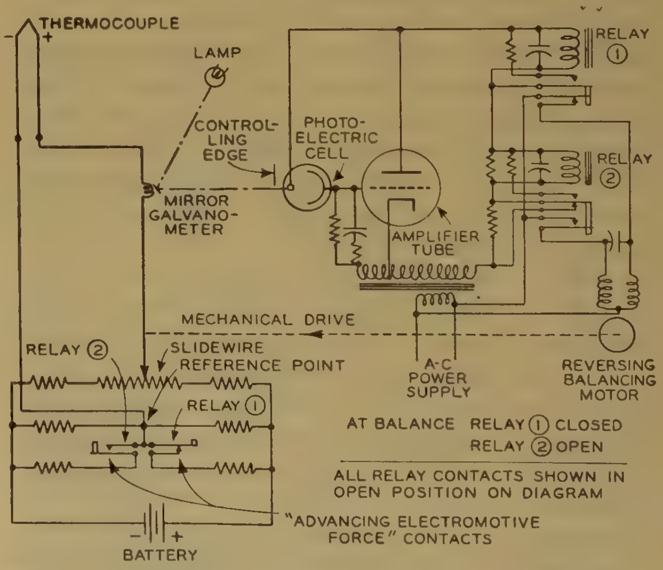
When the slide wire contact is above the null-balance point, the opening of relay 1 raises the potential at the reference point so the galvanometer again reaches the null position before the potentiometer is balanced fully and the final balance point is reached with small stepping actions.

A Foxboro "Dynalog A-C Bridge Recorder" is illustrated in Figures 5 and 6 in which a modified Wheatstone bridge circuit is used. This bridge is energized with 1,000 cycles per second alternating current generated by a vacuum tube oscillator of conventional design. A novel feature of this circuit is the use of a variable air capacitor instead of a slide wire for the balancing arm of the bridge.

The a-c unbalance voltage from the bridge is impressed directly on the control grid of the first tube of a three-stage amplifier of conventional design. The amplified voltage from the output of the third stage is approximately proportional to the magnitude of bridge unbalance up to the point where the amplifier overloads and it reverses phase as the rotor of balancing capacitor passes through the bridge balance point.

The amplified unbalance voltage is impressed on both grids of a twin triode tube, which functions as a phase discriminator. The plate voltages for the two triode units of this tube are 1,000 cycles per second alternating current supplied from the same oscillator which feeds the measuring bridge circuit. These two plate voltages are 180 degrees out of phase, thus any unbalance voltage applied to the grids will be in phase with one plate voltage and 180 degrees out of phase with the other one. In the triode unit in which the grid and plate voltages are in phase, a large pulsating rectified a-c plate current will flow and a large voltage will appear across the plate load resistor. In the other triode unit, the grid will be negative when the plate is positive and the plate current and output voltage will be small or even may fall to zero. By the use of large capacities shunted around the plate load resistors, the output voltages are made substantially direct current.

With a suitable network, the algebraic difference between these two output voltages is split equally and applied as two equal but opposite in sign d-c bias voltages to the grids of a twin-triode power amplifier tube. Connected in the plate circuits of these two triode units are


THERMOCOUPLE
-
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LAMP
CONTROLLING EDGE
PHOTO-ELECTRIC CELL
MIRROR GALVANOMETER
AMPLIFIER TUBE
RELAY ①
RELAY ②
MECHANICAL DRIVE
RELAY ②
SLIDEWIRE REFERENCE POINT
RELAY ①
A-C POWER SUPPLY
REVERSING BALANCING MOTOR
AT BALANCE RELAY ① CLOSED
RELAY ② OPEN
ALL RELAY CONTACTS SHOWN IN OPEN POSITION ON DIAGRAM
"ADVANCING ELECTROMOTIVE FORCE" CONTACTS
-
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BATTERY

Figure 4. Tagliabue Celectray self-balancing potentiometer

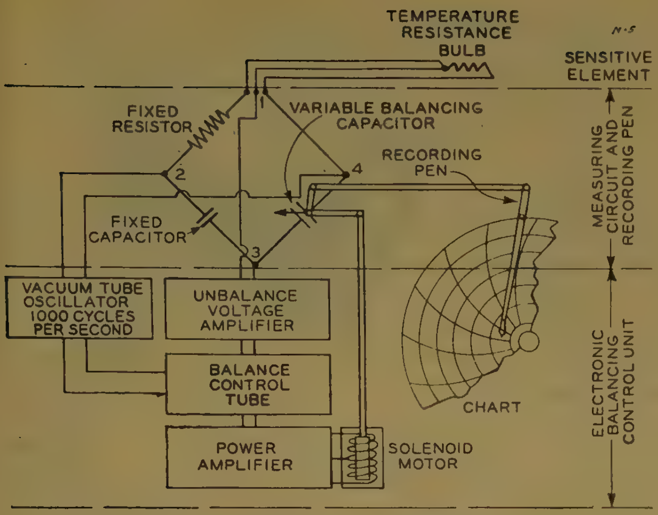

TEMPERATURE RESISTANCE BULB
SENSITIVE ELEMENT
FIXED RESISTOR
VARIABLE BALANCING CAPACITOR
1
2
3
4
RECORDING PEN
FIXED CAPACITOR
MEASURING CIRCUIT AND RECORDING PEN
VACUUM TUBE OSCILLATOR 1000 CYCLES PER SECOND
UNBALANCE VOLTAGE AMPLIFIER
BALANCE CONTROL TUBE
CHART
POWER AMPLIFIER
SOLENOID MOTOR
ELECTRONIC BALANCING CONTROL UNIT

Figure 5. **Foxboro Dynalog self-balancing bridge**

the two coils of a reciprocating magnetic motor. This motor consists of a pair of solenoid coils surrounding a cylindrical iron core which is connected by a rigid drive link to the balancing capacitor rotor. Because of suitable design, the magnetic force exerted by the coils on the moving core is practically independent of core position and is proportional only to the square of the currents in the two coils.

At bridge balance (when there is zero input alternating voltage to the discriminator tube), equal direct currents flow in the two motor coils and the balancing capacitor is held at the correct position through a force balance in the magnetic motor. Any bridge unbalance voltage is amplified and unbalances the two motor coil currents to drive the core and balancing capacitor rotor to the correct new balance position.

The distinctive feature of this instrument is in the mechanical design of the balancing system to obtain simplicity and to eliminate certain maintenance problems rather than in the electronic circuit used. Figure 6 shows the balancing capacitor magnetic drive motor and the recording pen movement, with the two links connecting these units.

BROAD TRENDS

In summary, some personal opinions are offered on current trends in process instrumentation, especially in relation to the various new types of electronic instruments mentioned.

There is a general increase in the proportion of electric process instruments being used and there is every reason to expect that this trend will be accelerated by the development of electronic instruments. Some of the factors responsible for this swing are the following:

1. More accurate measurement.
2. More sensitive measurement.
3. High recording speed.
4. Measurement of variables impossible with mechanical instruments.
5. Separate sensitive elements and instruments and low priced, easy, and quick replacement of sensitive elements without removing instrument.
6. Elimination of capillary tubing and static pressure lines.
7. Instantaneous transmission of measurements.
8. Multiple measurements with a single instrument and a selector switch.
9. Addition, subtraction, or ratio computations with special measuring circuits.

Beyond these factors, all of which now are realizable, is the hope of getting a truly universal instrument which would measure all process variables by changing the sensitive element and some measuring circuit elements.

In control mechanisms and final control elements there is no immediate prospect of electrical or electronic techniques superseding the pneumatic equipment which now largely dominates the process field. Electric control mechanism now predominate only in a few specialized fields such as heat-treating and where electric control does have obvious advantages because of the nature of the controlled equipment, for instance, motor starters or electric heating elements.

One important factor in this picture is the relative availability of suitable pneumatic and electric final control elements which are valves for the control of fluid flow in a great majority of process control applications. Electrically operated valves generally use either a solenoid or an electric motor drive. Pneumatic types of valves use a spring opposed diaphragm air motor. In general, the pneumatic types are less expensive, more simple and sturdy, and require less maintenance. In addition, they are not an explosion hazard and do take a positive position in case of air failure.

Another factor is the relative performance of electric and pneumatic control mechanisms in proportional or proportional plus reset control action types. In the present situation better results can be obtained with pneumatic mechanisms on most process applications. It is a rather difficult problem to obtain with electrical networks the slow reset action needed for many processes.

Much work has been done during the war on electric and electronic servomechanisms for use in fire control, stabilizing mechanisms, for guns, bombsights and other mechanisms, radar equipment, and airplane flight control. It well may be that out of these developments will come suitable low-priced electric valve operators, while other approaches to the controller problem, as the use of pneumatic-electric or mechanical-electric reset mechanisms, may give satisfactory results.

The field of direct operated process electric control equipment is relatively undeveloped. In the mechanical equipment field, there are available low priced self-operated pressure and temperature regulators which use power supplied from the controlled medium. Practically all electric control mechanisms operate from the movement or the position of a pointer or recording pen on a mechanical or electric measuring instrument. However, there are already signs that all-electric control equipment, in which the measuring circuit and the controlling circuit are combined in a single unit to give an instrument with a calibrated setting mechanism but without indication or record of the controlled variable, will be placed on the market during the postwar period.

There is a growing tendency for the fields covered by the process instrument companies and by electric equipment manufacturers to meet and overlap.

On one hand, the process instrument companies are getting into the measurement of what might be called "mechanical" variables and the control of prime movers or power transmission equipment instead of merely valves. Typical examples are: automatic operation and safety control or motor driven pumping equipment; torque measurement on centrifugal filters, agitators in reaction vessels, pulp washers, and so forth; load and mechanical pressure control on pulp beaters, calendars, squeeze rolls, and so forth; tension control on paper, cloth, cellophane, or rubber sheets in process.

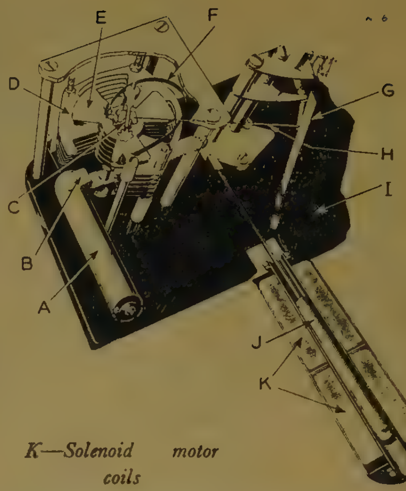
On the other hand, the electric equipment companies are developing new control mechanisms which are highly useful with suitable measuring instruments. Examples are the many types of electronic motor speed control equipment. Also useful are many electronic relays, timers, and standard photoelectric cell pickup and control units.

It is evident that this development of a common field of work makes important the use of a common terminology for automatic control equipment. The terminology used by electrical engineers apparently has been taken over intact from the field of turbine speed governing. That used in process control has been far more casual in growth and has been semicodified only during the past several years by the instrument group in The American Society of Mechanical Engineers.

There still is a decided conflict between these two accepted sets of control terminology. Examples are the different usage of such words as "control" and "regulation." Another example is the use of two different words for the same meaning, as in the case of control point "droop" and "drift."

The use of two different sets of terminology to describe the same behavior of control equipment only confuses the users and purchasers of this equipment. It also makes the growth of a common understanding between electrical and mechanical engineers more difficult. Also, the use of a common terminology does have a special importance at this time because of the increasing use of both electrical and hydraulic analogues to interpret and predict the transient behavior of both chemical processes and mechanical equipment under automatic control.

One final opinion might be ventured as to the extent to which electronic instruments will replace mechanical types. In this period following the war, there undoubtedly will be a considerable number of new types of electronic measuring and controlling instruments placed on the market. Many of these will be marketed by companies building standardized units for sale in package form but equipment selling of this type also means very little application engineering by the maker. As a result, this class of equipment may do more harm than good to the general use of electronics in industry until users develop their own "know-how" on electronics.



A—Counterweight and dashpot
B—Balancing capacitor drive crossarm
C—Adjustable drive lever
D—Balancing capacitor stator
E—Balancing capacitor rotor
F—Pigtail connection to rotor
G—Pen arm
H—Pen arm drive link
I—Base plate
J—Solenoid motor core
K—Solenoid motor coils

Figure 6. Foxboro Dynalog self-balancing a-c bridge construction of balancing capacitor, drive motor, and recording pen

If history is any teacher, there will be a temporary swing to the use of these instruments because of advantages of mechanical simplicity and better control action. However, looking at the examples of motor speed control and electric welding control, this swing will stimulate the development of other mechano-electric and pneumatic mechanisms to the point where competition between these types will be based on economic factors. It is possible that the majority of the dollar volume of instrument business in this way will be reduced to package sales. Certainly the development of a universal electronic instrument, as mentioned previously, which could be produced in quantity, would have a strong influence in this direction.

There is a large segment of the process instrument market which does not appear likely to fall into this classification. This is the petroleum refining and the chemical market. In these fields an intangible and extremely important part of the sale price of instrument equipment has been the engineering of automatic control, including advice on desirable changes in process equipment to make better control possible. It almost can be said that the difference in relative success between the various instrument companies has been in the quality of the engineering service which they supplied to their customers.

A Laboratory for Basic Electronics

P. M. HONNELL   W. E. STROHM

The United States Military Academy now has a 140-position electronics laboratory in which future Army officers are given instruction in a field that has greatly influenced modern warfare. Provision is made for supply from central sources, to each student position, of alternating and direct voltages, including radio frequencies up to 18 megacycles per second, with suitable protective measures.

THE MECHANIZATION of modern warfare has affected all echelons of the Army, and one result of this trend has been the progressive modification of the program of instruction at the United States Military Academy to keep abreast of technological developments. For example, the increased importance of electronic devices in military equipment has necessitated the lengthening of the course in electrical engineering fundamentals given at the academy to provide for greater emphasis on the basic theory underlying these devices.

Since all cadets at West Point pursue an identical program of studies, the size of the classes is rather large; the first class (in which the course in electricity is at present scheduled) comprises over 850 cadets, although each instructor teaches a section usually not exceeding 15 cadets. Naturally with such large numbers of students, teaching facilities must be quite extensive and involve many unusual problems, not the least of which is the requirement of uniformity of instruction. This is achieved by close control and co-ordination of all instructors and by laboratory apparatus and equipment which is as uniform as possible for all sections.

It is evident that the problems involved in the laboratory phases of instruction necessarily require a different approach and solution than is possible in the usual civilian college. This is particularly true for the course in electricity in which individual laboratory work is emphasized. The purpose of this article is to describe a new 140-position electronics laboratory, shown in Figure 1, especially designed to provide large-scale laboratory facilities for the instruction of cadets in electronics and communications at an introductory level.

DESIGN CONSIDERATIONS

An important feature of electrical laboratories is the supply and distribution of electrical power. For electronics experiments this may require most of the following supply sources: filament or heater voltage; plate and screen voltage; grid biasing voltage; and, depending upon the particular experiment, audio-frequency or radio-frequency signal voltages. In many laboratories these varying voltages are furnished to each student by individual power supplies and signal sources, each of which usually is operated from a 115-volt 60-cycle power circuit. The power distribution problem therefore resolves itself to furnishing a suitable number of outlets for this facility, with some additional tie lines.

In a 140-position laboratory, however, this method of supplying the array of voltages requires an excessive investment in power supply and signal source apparatus and is extravagant of bench-top space which is always at a premium. Furthermore, the storage, issue, and servicing of the large numbers of power supplies and signal sources in addition to the laboratory equipment required for the various experiments entails considerable administrative difficulties. Finally, for a basic course, much is gained by minimizing the amount of auxiliary apparatus in use by the cadets, so as to focus their attention on the fundamental electrical principles and objectives of the particular experiments performed.

To meet the special needs of the West Point laboratory, centralization was adopted for all power supplies and audio-frequency and radio-frequency signal sources in a single group of units of sufficient rating to feed 140 stations simultaneously. Additional separate signal sources sometimes required also are included for multiple use, usually by bench groups under control of individual instructors.

The successful utilization of centralized power and signal sources requires a flexible distribution system. A compromise between flexibility, space, and economic factors was reached by placing all circuits to any one bench on a common set of busses, the busses terminating on the switchboard by bench groups. This arrangement permits the simultaneous performance of different experiments on each bench. On the other extreme, the 140 cadet stations can be connected in parallel to the supply sources for common experiments by all. Conveniently located control pedestals on each bench contain circuit supervisory and overload protection for use by the in-

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The project described in this article was undertaken at the direction and under the supervision of Colonel Chauncey L. Fenton, professor of chemistry and electricity at the United States Military Academy, and the authors acknowledge his interest in and support of the project. The keen interest of the Chief Signal Officer of the Army in the ultimate objective of this laboratory—the training of future officers of the Army in basic electronics and communications theory—has been reflected in the outfitting of the laboratory with many critical and specialized items by the Signal Corps.

structors. These are supplemented by individual switches on each circuit at the cadet stations.

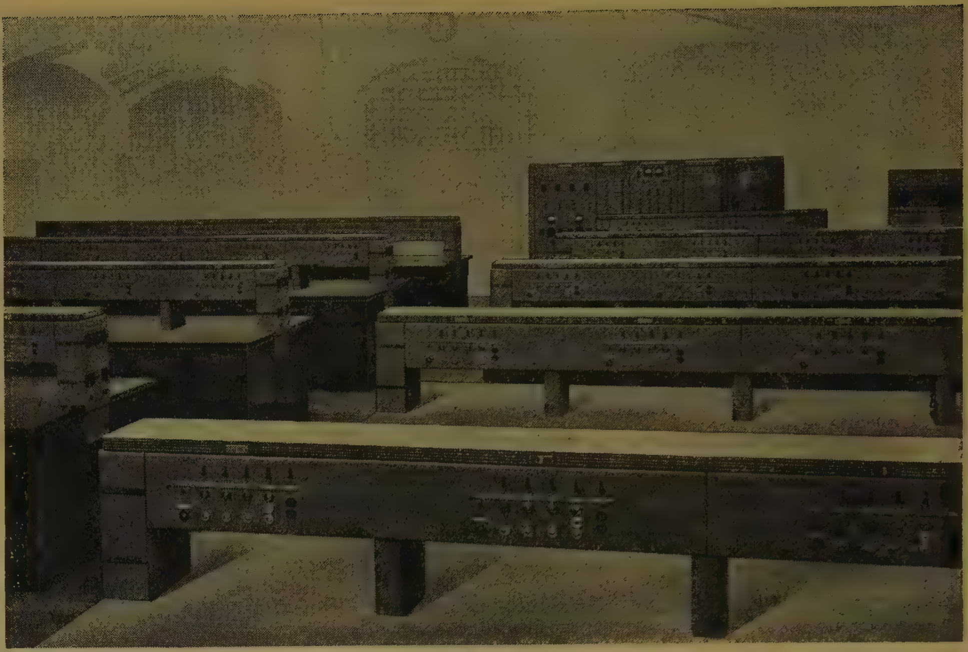


Figure 1. View of the electronics laboratory

LABORATORY

The laboratory is about 64 feet wide by 72 feet long and includes in the major unit category a main switchboard, a 5-channel radio-frequency oscillator, and 12 laboratory benches with superstructures. As shown in Figure 2, the equipment is executed in a modern styling; it is finished in a smooth lacquer enamel with the vertical planes in a light gray color and the horizontal planes in a darker tone.

A level of 30 foot-candles on the bench-top surfaces from indirect-lighting fixtures provides adequate illumination for reading instruments without masking the traces on the screens of cathode-ray oscillographs.

The benches are 5 feet wide by 20 feet long and each can accommodate a maximum of 12 student cadets at 6 stations on a side. The cabinets under the benches provide storage space for the instruments, electronics equipment, and cathode-ray oscillographs.

The bench units, Figure 3, are constructed of 1/8-inch steel in three sections bolted together and supported on pedestals above the bench tops. This arrangement permits practically the entire bench-top surfaces to be utilized for apparatus, and in addition provides a shelf one foot wide the full length of the bench. All wires and cables are contained within the steel trough; access for maintenance merely requires removal of the top cover. At each cadet station the distribution circuit terminals are grouped together and clearly designated by engraved legend plates. The terminals are special tri-pin jacks, described hereinafter, mounted on the grounded steel bench unit by colored plastic insulators.

The following distribution circuits terminate at each cadet station:

Number of Circuits	Type of Circuit	Circuit Designation
1	Single-wire circuit	CKT-0
3	Two-wire circuits	CKT-1 CKT-2 CKT-3
1	Three-wire circuit	CKT-4
1	Duplex convenience receptacle	115 volts alternating current
1	High-frequency coaxial cable	HF
4	Ground jacks	GND

Except for CKT-0, each wire circuit is controlled at the station by a flush-mounted tumbler switch of the type used in lighting circuits.

Figure 4 is a schematic circuit of a complete bench distribution circuit, and indicates the feeders from the switchboard entering the bench unit through the instructor's control pedestal in which are localized the magnetic circuit breakers for switching and overload protection on the bench circuits as a whole, together with neon pilot lights for supervision.

SWITCHBOARD

The totally enclosed switchboard, shown in Figure 5, comprises five bays.

The following power sources terminate in the power bay:

Fixed voltages:

115 volt alternating current, 60 cycles single phase, 225 ampere capacity

208 volt alternating current, 60 cycles single phase, 150 ampere capacity

240 volt direct current, 150 ampere capacity

Adjustable voltages:

2 120-volt 200-ampere-hour storage battery banks tapped every four volts

2 0–115 volt 60-cycle single-phase variable transformers

The storage batteries are an excellent source of plate voltage for electronics experiments and usually are connected in series for this purpose. The variable transformers of 50-ampere rating each are the counterpart of the storage batteries in flexibility for electronics and communications experiments. Circuit breakers are provided on both input (time delay) and output (instantaneous) to provide immediate protection. A voltage multiplier ganged with the control knob of the variable transformer is switched automatically to provide factors of 1, 4, and 10 in the indication of a 0–15 voltmeter.

An isolating transformer is connected permanently in tandem with each variable transformer.

The transfer bay provides four sets of paralleling jacks. These are particularly useful when transferring a given power supply to a group of bench circuits, especially at a high amperage. Distribution circuits to the 12 benches terminate on the distribution bay.

The audio-frequency bay is arranged for mounting of $6^1/_2$ linear feet of standard 19-inch relay-rack equipment. The apparatus mounted includes a beat-frequency oscillator providing audio-frequency voltages from 20 to 40,000 cycles per second at a maximum of one watt output; two booster amplifiers useful up to 10,000 cycles per second, each with a 60-watt output; a voltage-level metering panel; a radio receiver for obtaining standard frequency transmissions from WWV (National Bureau of Standards); two loud speakers; and a patching panel for interconnecting the equipment. The apparatus on this bay is utilized as the primary source of audio-frequency power. When supplying the entire laboratory, the two booster amplifiers each are connected to feed six benches through high frequency coaxial lines and are driven by the beat-frequency oscillator. To reduce the effects of accidental short circuits (due to misconnections by cadets) an attenuator pad is placed in each of the coaxial lines being fed. (See Figure 6.)

The radio-frequency bay is arranged for relay rack mounting of equipment. A large panel carries the high-frequency terminal jacks for the coaxial lines. All coaxial lines are patched with corresponding size coaxial patch cords, with a suitable arrangement for changing from the 7/8-inch to the 3/8-inch line jacks.

PROTECTIVE MEASURES

Protective measures in laboratories are necessary and important for the safety of personnel and equipment; an added consideration in this laboratory is prevention of lost time from circuit interruptions. An improperly made connection at any one station could result in impairing the operation of the remaining 139 stations. Faults therefore must be localized quickly to preclude disruption of the entire laboratory. This is achieved by means of the magnetic-type circuit breakers located on the instructor's control pedestals which restrict faults to the respective benches at which they occur.

Personnel. By its very nature, apparatus for experimental use is exposed to personnel and the best that can be done in a laboratory is to limit the voltage sources to reasonable values; to ground properly all exposed metal panels and frameworks including switchboards and bench units; to provide conveniently located switches for removing power while making or when changing circuit connections; and to discipline instructors and students alike in the habitual use of these switches and in keeping a "hands off" attitude when power is applied to the exposed apparatus. These are standing operating procedures in the installation described.

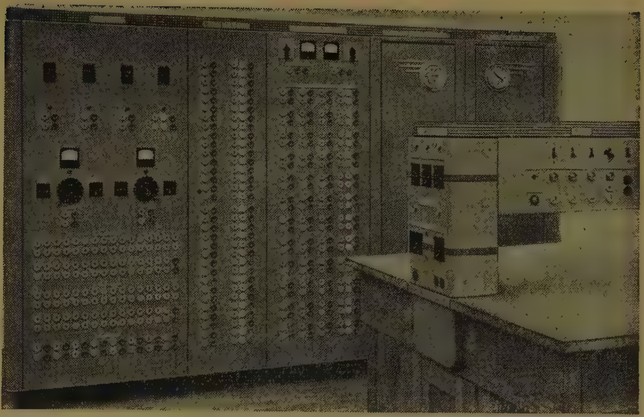


Figure 2. Main switchboard and bench unit

Apparatus. For electronics apparatus it is highly desirable to limit fault currents to much smaller values than 35 amperes, the limit of the circuit breakers on the control pedestals. It has been found practicable to use tungsten-filament incandescent lamps as current-limiting devices for this purpose. One lamp is placed in series with the appropriate wire of each bench distribution circuit to be protected. Thus when a fault occurs on a particular bench, only those stations paralleled on that bench are affected, and full voltage thereby is maintained on the remaining benches.

Although the entire load current for a given bench passes through a current-limiting lamp, any voltage varia-

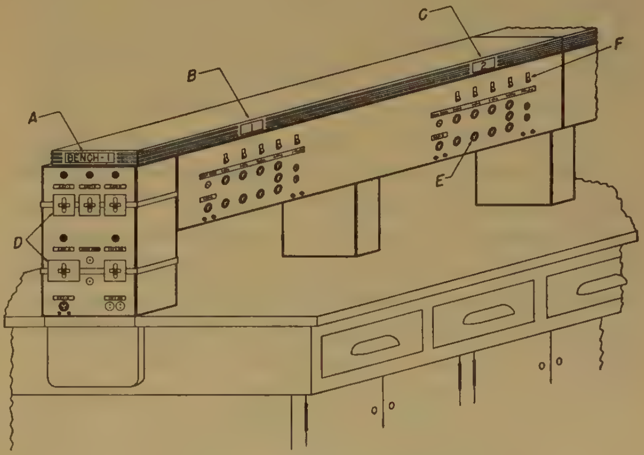


Figure 3. Bench unit details

A—Instructor's control pedestal
B, C—Cadet stations
D—Magnetic circuit breakers
E—Tri-pin jack terminal
F—Tumbler switch on individual wire circuit

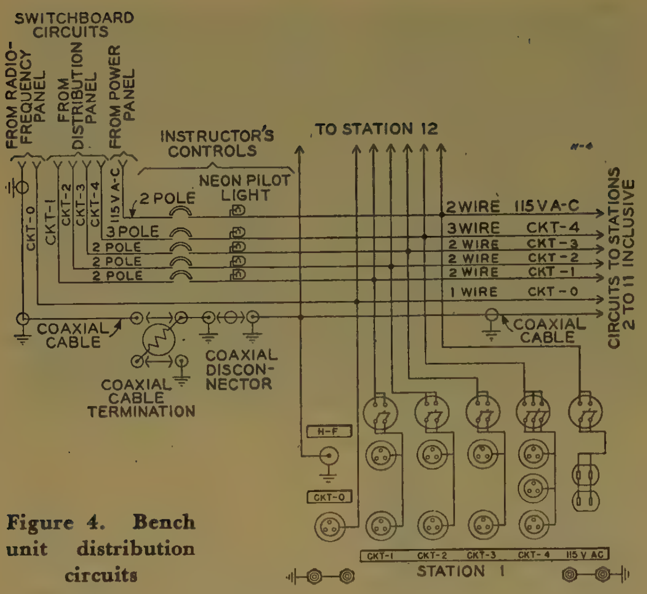


Figure 4. Bench unit distribution circuits

tion thereby introduced in the bench circuit is generally speaking negligible since the cold resistance of the lamps is only of the order of ten per cent of their hot resistance. These lamps have not been mounted permanently in the switchboard, but instead are plugged into the appropriate jack of each distribution circuit on the distribution panel of the switchboard by means of a special plug-in socket, thereby permitting complete freedom in the use of these devices.

AUXILIARY VOLTAGE SOURCES

In many electronics experiments, special supply voltages are required in addition to those permanently terminating on the main switchboard. For instance experiments on single-phase full-wave rectification require a transformer of suitable rating with a center-tapped secondary winding for distribution on a three-wire basis. Since these special voltage sources are rather bulky and often required for only a few experiments, it would be uneconomic to include them in a permanently wired arrangement; therefore they are constructed as mobile units and provided with integral circuit breakers. When required for an experiment these special power supplies are connected to the power and distribution bays on the switchboard by patch cords. This method of providing special power sources leads to a great simplification in the switchboard circuits proper and allows for considerable flexibility when making changes or additions to the laboratory experiments and procedures.

RADIO-FREQUENCY OSCILLATOR

The 5-channel radio-frequency oscillator included as a permanent part of the laboratory installation makes possible the distribution of radio-frequency energy to each of the 140 stations at a fairly high power level, and places the distribution of radio-frequency power somewhat in the same category as the distribution of 1,000-cycle power. The oscillator consists of a main rectifier power supply; a dual modulator; four identical high-frequency oscillator-power amplifier channels capable of 100 per cent amplitude modulation at a carrier level of 300-watts each with carrier frequencies from 2 to 18 megacycles per second; one 600-watt channel for carrier frequencies between 150 and 500 kilocycles per second, also capable of 100 per cent modulation. Any four of the radio-frequency channels can be operated simultaneously, with two of them independently amplitude modulated. The carrier frequencies may be controlled either by electrical master oscillators, or by quartz crystal oscillators, thereby providing any desired carrier frequency to be used in the bands enumerated in the foregoing. Crystal oscillators provide exact carrier frequencies, usually chosen at exactly 2, 10, and 18 megacycles per second, thereby facilitating quantitative measurements in experiments.

The entire installation is shielded completely with the oscillator housing as well as all other large conducting surfaces carefully bonded together and to the earth. Since the output leads from the oscillator are coaxial-type cables the spurious radiation from the entire system is of negligible proportions up to the actual cadet stations, where necessarily some of the apparatus is unshielded. This applies to tuned circuits particularly, since in elementary work much is gained pedagogically by simplifying the apparatus as much as possible—and this means no shielding.

COAXIAL DISTRIBUTION SYSTEM FOR HIGH-FREQUENCY POWER

Uniform distribution of high-frequency power is accomplished by means of the coaxial transmission line distribution circuits. Supplying an isolated load through

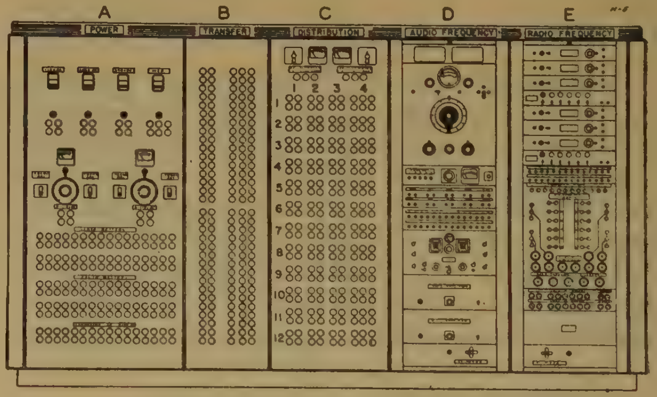


Figure 5. Main switchboard

A—Power bay, showing circuit breakers and jacks for fixed voltages, variable transformers, and storage battery taps
B—Transfer bay
C—Distribution bay
D—Audio-frequency bay, showing beat frequency oscillator, volume level meter, jacks, radio receiver, and audio power amplifiers
E—Radio-frequency bay, showing remote controls for radio-frequency oscillator and jack panels

a coaxial line merely requires that the load impedance be matched to the surge impedance of the coaxial cable to secure a maximum power transfer without frequency discrimination. When several loads are to be fed from the terminus of a single coaxial line—actual conditions on the benches may require the supply of a maximum of 12 stations—the problem is somewhat more difficult, since each of the loads must obtain its proportional share of the available power. Furthermore, 12 such coaxial lines with their multiple loads may be in use at one time in the laboratory. Impedance matching must be maintained and impedance discontinuities avoided on all the coaxial cables if the parallel operation of 140 station outlets is to be accomplished satisfactorily. Separate gas-tight 3/8-inch copper coaxial lines, ceramic insulated, of 72 ohms surge impedance connect each of the 12 benches to the radio-frequency bay of the main switchboard. At the switchboard, coaxial jacks permit the patching of the benches in any desired manner to the audio- or radio-frequency oscillators. On the instructors' control pedestals, coaxial patch-cord disconnectors are included; these are the high-frequency equivalents of switches and serve the same purpose.

The shielded termination boxes contain a 73-ohm noninductive resistor capable of dissipating 100 watts (see Figure 6) and a banana-jack arrangement which, with plug-in short-circuiting bars and resistor elements, permits a wide variety of terminations of the coaxial lines. These include shunt and series connections of the terminating resistor and L, T, or π attenuation pads. Thermocouple ammeters also may be plugged into the termination circuits.

Audio-Frequency Distribution. For many audio-frequency experiments, the loads are of the high-impedance bridging type, and the necessary power is of negligible proportions; only a definite signal voltage at a low impedance level, and of known frequency, is then required. This may be obtained in several ways. At frequencies up to 10 kilocycles per second, the lines may be left unterminated when supplied by the low internal impedance outputs of the oscillator or power amplifiers. When frequency discrimination is to be avoided the coaxial lines may be terminated in their surge impedance—73 ohms—by means of the resistors in the termination boxes. The high-impedance loads then are bridged across the 73-ohm termination. If only a few volts are required then a simple attenuator pad arrangement as shown in Figure 6 in place of the 73-ohm terminating resistor will reduce the voltage at the bench to the desired level. At the same time this attenuator provides a measure of isolation between benches so that accidental short circuits on any one bench will not affect the other stations by more than a few per cent.

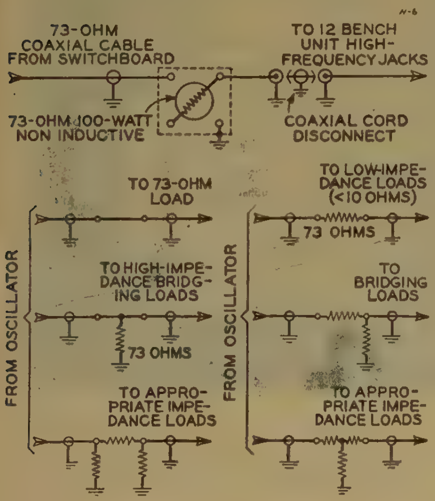

N-6
73-OHM COAXIAL CABLE FROM SWITCHBOARD
TO 12 BENCH UNIT HIGH-FREQUENCY JACKS
73-OHM 100-WATT NON INDUCTIVE
COAXIAL CORD DISCONNECT
TO 73-OHM LOAD
TO LOW-IMPEDANCE LOADS (<10 OHMS)
73 OHMS
FROM OSCILLATOR
TO HIGH-IMPEDANCE BRIDGING LOADS
73 OHMS
FROM OSCILLATOR
TO BRIDGING LOADS
TO APPROPRIATE IMPEDANCE LOADS
TO APPROPRIATE IMPEDANCE LOADS

Figure 6. Methods of terminating high - frequency coaxial distribution cables

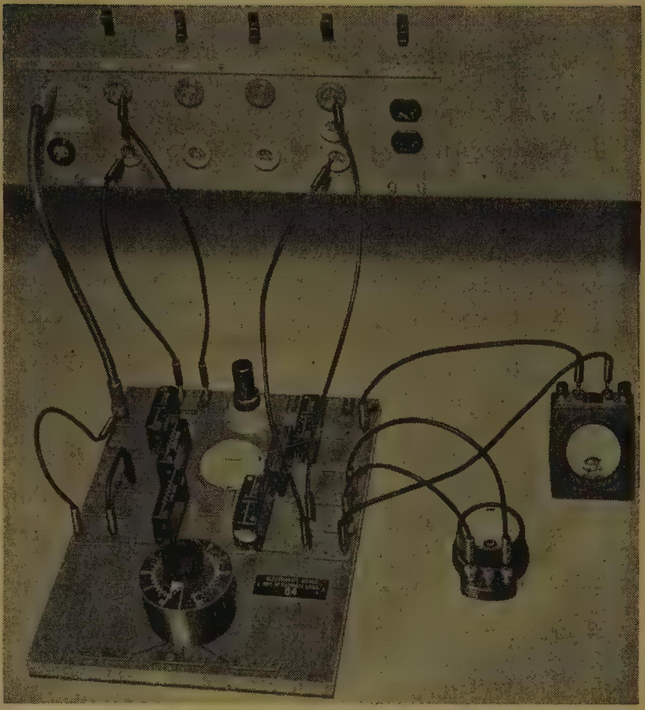


Figure 7. Electronics experiment board connected to bench unit

Radio-Frequency Distribution. The multiple distribution of radio-frequency energy on a basis of equality to 140 positions is naturally more difficult than at lower frequencies because of the effects of impedance discontinuities. Paralleling of the unequal-length coaxial lines at the switchboard requires each line to be terminated in its surge impedance; each then will present a purely resistive load to the oscillator. Since the lines are all of identical surge impedance they present equal resistances and thereby obtain equal shares of the radio-frequency power.

In basic radio-frequency experiments, two types of radio-frequency energy supplies are required: one on an equal voltage basis to all stations, and one on an equal ampere-turn basis for inductively coupled loads. One satisfactory method of furnishing equal voltages to all stations is to terminate each coaxial line in an L pad at the termination boxes. This is necessary because the 12 multipled high-frequency jacks and the associated coaxial patch cords on each bench introduce capacitive components shunting the 73-ohm terminating resistors of each line, with the result that the voltages at the benches differ widely due to the unequal line lengths. By placing this capacitive component across the low resistance shunt arm of the L pad this effect is rendered negligible and all benches receive equal voltages; furthermore, this introduces the beneficial isolation between benches previously mentioned.

The method devised for energizing the coupling coils overcomes the effect of the 20-foot length of the benches by paralleling each coil with a capacitor to antiresonate the coil and its proportional share of the coaxial cable and junction-box capacitances. With properly chosen identical coils and capacitors at each station the entire bench circuit is resonated. Thus the coaxial distribution lines are terminated in their characteristic impedances—73 ohms—while the reactive volt-amperes in the tuned circuits are confined to the bench circuits proper. Taps are brought out on the coupling coils such that several voltages are available at a constant level at each station.

APPARATUS CONNECTIONS

The successful operation of a large electronics laboratory depends upon many factors, among which may be mentioned the purely practical one of interconnecting apparatus. This problem exists because the electrical and radio industries never have standardized upon a few types of connectors with the result that many varieties of binding posts, banana plugs and jacks, and other types of connections are furnished on commercial laboratory instruments and equipment.

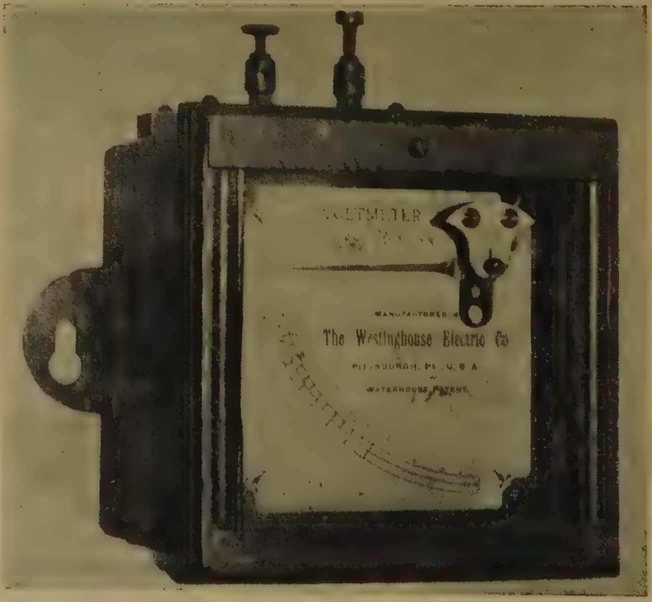
At West Point a long maintained policy has been the use of tapered pin plug and jack connectors of large capacity for the power laboratories, with a smaller version suitable for electronics and communications apparatus. By using a few standardized cord lengths tipped with tapered pin plugs on both ends and providing multiple tapered pin jacks on all equipment, great flexibility of connections is possible, connections are made easily and quickly, and electrical contacts are uniformly good. Of course it is a considerable undertaking initially to provide equipment with the tapered jack. For instance, all new instruments must be provided with the multiple jacks; while on other equipment use sometimes is made, as an expedient, of strips of brass with two or three holes reamed to the proper taper fastened to the apparatus.

The terminals on the bench units also were designed to utilize the same type of tapered pin connectors, each distribution line terminal being provided with a three-hole pin-jack arrangement (thus the name tri-pin jack). The tri-pin jack body is of machined brass, chrome plated, and has the three tapered pin holes at an angle to the face of the jack. The jack bodies are fastened in color-coded insulating bushings which mount the terminals and insulate them from the grounded steel framework of the bench units. One of the simpler triode amplifier circuits is shown in Figure 7 connected to the bench unit from which the heater, plate, and signal voltages are distributed. The method of providing commercial instruments and experimental apparatus with tapered pin connectors is clearly evident; other obvious variations also are utilized extensively.

FLEXIBILITY OF PLAN

Although the problems discussed in this article are somewhat peculiar to the Military Academy in view of its mission, nevertheless they are basically the same ones encountered elsewhere. The simplicity and reliability of the method of achieving the design objective of the laboratory, that is, to provide the facilities for the efficient simultaneous instruction of over 100 cadets, each performing the same experiment, has been demonstrated by its successful operation during the past two years. Although it might appear that this laboratory is rather inflexible in view of its primary design objective, it will permit the scheduling of 12 totally different experiments concurrently—one on each of the 12 benches—and in addition it is possible to conduct each of the 12 experiments with ample facilities for 8 to 10 cadets.

It is considered likely that some features of the installation described could be incorporated profitably in the plans for the modernization or new construction of educational or industrial electronics laboratories.



Westinghouse photo

Original a-c-d-c instrument of the moving magnet type produced in 1888

Statistical Methods in Quality Control

IX. Acceptance Sampling

This article discusses acceptance sampling plans used in inspections performed by the method of attributes including single sampling, double sampling, and multiple sampling. It presents a number of typical "operating characteristics" of sampling plans.

MUCH ACCEPTANCE INSPECTION is conducted on a sampling basis. For example, a lot of 1,000 like articles is presented to an inspector for acceptance. He selects a sample of 75 articles from the lot, and inspects them. If he finds not more than one of the articles defective, he accepts the lot; if he finds two or more of them defective, he rejects the lot. He goes through the same procedure for each of a succession of lots, as they are presented to him, one by one.

Now, where sampling instead of complete inspection is used, certain errors or risks are unavoidable. One might ask, "What risks is the inspector taking in the foregoing sampling plan?," "Why not look at a sample of only 35 articles and accept the lot if no defects are found in the sample?," or "Why not merely a sample of 10?" Certainly the latter procedure would require less effort. We can get help in answering such questions by making use of certain probability laws.

It is the purpose of this article to consider some of these matters as they relate to acceptance sampling inspections performed by the "method of attributes,"[1] in which the acceptability of product is to be determined with respect to dimensions, finish, and other characteristics adaptable to nondestructive, "go-and-no-go" gauging, and visual inspections. The discussion has particular bearing on products which consist of individual articles of the same design and which are produced repetitively in quantity. Many of the principles outlined may be applied equally well to inspections performed by the "method of variables."[1]

We may speak of three types of sampling procedures: single sampling,[2] double sampling,[2] and multiple (or sequential)[3] sampling. In single sampling, only one sample of *n* articles is inspected in order to decide whether the lot should be accepted or rejected, and the acceptance criterion is expressed as an acceptance number, *c*, the permissible number of defectives in the sample. In double sampling, a second sample is permitted if the first fails, and two acceptance numbers are used; the first, c_1, applying to the observed number of defectives in the first sample alone, and the second, c_2, applying to the observed number of defectives in the first and second samples combined. In multiple sampling, third, fourth, fifth, or further samples are permitted, and at each step acceptance and rejection numbers are set forth, indicating whether the inspector should accept, reject, or take another sample.

One of the most satisfactory ways of showing risks involved in any sampling plan is to plot a curve known as the "operating characteristic" of that sampling plan. The heavy curve in Figure 1 shows such an operating characteristic for the single sampling plan mentioned at the beginning of this article, in which a sample of 75 articles is selected from each lot and inspected, and the lot is accepted if 1 or less defective articles are observed in the sample and rejected if 2 or more defectives are observed. This curve shows for any particular level of per cent defective in lots presented for acceptance what per cent of the lots will be accepted by the inspection plan. For example, if the quality presented is 1/2 per cent defective, the inspection plan will accept approximately 95 per cent of the lots, whereas if the presented quality is 5 per cent defective, the plan will accept only approximately 10 per cent of the lots. This percentage figure can be thought of as the "probability of acceptance," that is, 95 per cent means "the probability of acceptance is 0.95," or expressed another way, "the chances of acceptance are 95 in 100." The dotted curves on Figure 1 show operating characteristics for several

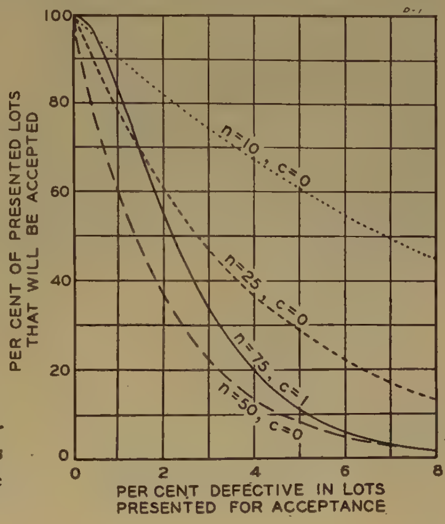


Figure 1. Operating characteristics for several single sampling plans

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One of a series of articles prepared in the AIEE subcommittee on educational activities and sponsored by the AIEE subcommittee on statistical methods.

Personnel of the AIEE subcommittee on educational activities: J. Manuele, H. F. Dodge, A. I. Peterson, and R. E. Wareham.

different single sampling inspection plans which have the same acceptance number, $c=0$ (for which no defectives are allowed in the sample) but have different sample sizes. This figure simply illustrates how a change in sample size alone affects the frequency of acceptance for products having different values of per cent defective.

Figures 2 and 3* give for purposes of reference the operating characteristics of single sampling plans with sample sizes varying from 3 to 50 and with acceptance numbers of 0 and 1.

Operating characteristics likewise may be constructed for double sampling and multiple sampling plans. For example, take a double sampling plan having a first sample of 50 and a second sample of 100, with acceptance numbers of 0 and 2 ($n_1=50$, $n_2=100$, $c_1=0$, $c_2=2$). To find the operating characteristic curve value for any particular value of per cent defective, we need to figure out and sum up the chances of acceptance for all possible ways that a lot can be accepted, as illustrated in Table I.

The operating characteristics for this double sampling plan is shown by the heavy dashed line in Figure 4. On the same chart a solid line shows the operating characteristic for the single sampling plan referred to earlier, namely, $n=75$, $c=1$. These two characteristics are substantially the same, indicating the feasibility of setting up single and double sampling plans having essentially the same risks. Two other plans are shown on Figure 4 by dotted lines. The amount by which the double sampling curves on Figure 4 are above the single sampling curve $n=50$, $c=0$ (which corresponds precisely to the contribution of the first sample in the double sampling plans under discussion) shows the increase in probability of acceptance contributed by permitting a second sample.

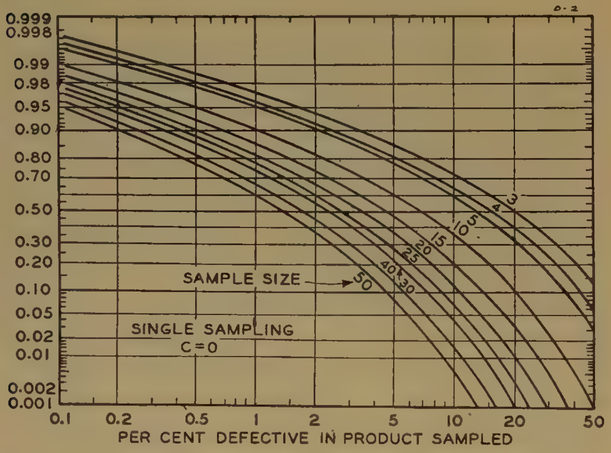

Figure 2. Operating characteristics—single sampling, $c=0$

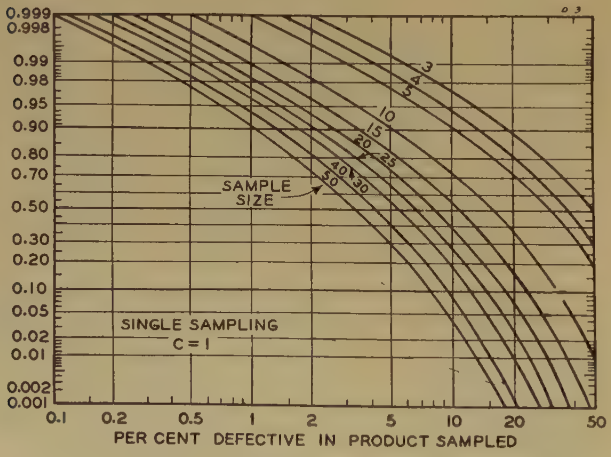

Figure 3. Operating characteristics—single sampling, $c=1$

Table I. Computation of Probability of Acceptance—Double Sampling Plan: $n_1=50$, $n_2=100$, $c_1=0$, $c_2=2$

Number of Defectives		Probability of Acceptance		
In First Sample	In Second Sample	For 1/2 Per Cent Defective Product	For 5 Per Cent Defective Product	
0		0.779	0.082	Accepted by first sample
1	0 or 1	0.177	0.008	Accepted by second sample
2	0	0.015	0.002	
Total (probability of acceptance for the plan)		=0.971	0.092	

In general, double sampling is preferred to single sampling on two counts:

1. It will provide the same protection with a smaller average amount of inspection.

2. It has certain psychological advantages, associated with the tendency to look with favor on a plan that permits a "second chance" to make good, particularly when an initial failure is marginal.

In turn, multiple sampling[5] will involve somewhat less inspection than double sampling for a given degree of protection, although often much of the gain over single sampling results from taking the second sample. Factors, other than those relating to amount of inspection, that often are controlling in the choice between double sampling and multiple sampling include: simplicity, cost of selecting samples, record keeping, training of inspectors, need for selecting samples large enough to insure representativeness, and psychological preferences of inspectors.

Systems of acceptance quality control making use of the afore-mentioned procedures have been developed, and sampling inspection tables published to accomplish certain over-all objectives. Among these systems may be mentioned one[2] which assures the inspector that no matter what quality is presented for acceptance, the *average* outgoing quality (AOQ) after inspection will not be poorer than some stated limiting value of per cent defective, designated the average outgoing quality limit (AOQL), and which attains this objective with a minimum average amount of inspection. With this procedure it is required that any lot which fails to be accepted by sample be inspected 100 per cent and cleared of de-

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* Reproduced by permission from reference 4.

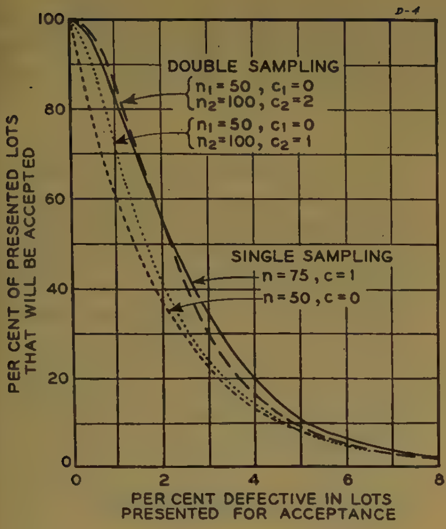

Figure 4. Comparison of single and double sampling plans

fects thus found. This type of plan is adapted particularly to use in process and final inspections in a manufacturing plant where one department produces and a subsequent department consumes the product. Another system,[5] widely used during the past three years by the armed services in the procurement of ammunition and other war matériel, carries the concept of an "acceptable quality level," that is, the maximum per cent defective which a manufacturer can be permitted continually to present for acceptance. With this system, three inspection plans are provided—normal inspection, more exacting inspection, and reduced inspection—the one to be used at any time depending on the relation between the actual quality level at that time and the acceptable quality level.

In evaluating such acceptance quality control systems, as applied to a continuing or intermittent supply, many factors must be considered. A system does not have a single operating characteristic in the usual sense, but this factor may be represented by a group of operating characteristics corresponding to the two or more sampling plans included therein. Other factors include such things as the use of recent past history, the process average quality, and the degree of stability or control, inasmuch as these systems encompass the notion of a series of lots presented over a period of time. They contain provisions for adjusting the amount and severity of inspection according to the general level of quality currently being presented for acceptance, as determined from a continuing analysis of inspection results. All such features require evaluation when comparing one system with another.

REFERENCES

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3. Sequential Sampling Inspection for Attributes, **H. A. Freeman.** *Industrial Quality Control*, September 1945, pages 3–7.

4. Acceptance–Rejection Requirements in Specifications, **H. F. Dodge.** *Proceedings* of the American Society for Testing Materials, volume 34, part 2, 1934.

5. Quality Through Inspection, **G. R. Gause.** *Army Ordnance*, July–August 1943 pages 117–20.

Mechanical Calculator Developed at Cambridge

A gigantic calculating machine, designed to solve mathematical problems that ordinarily would take trained computers many weeks, has been developed by the Massachusetts Institute of Technology, Cambridge. This new instrument deals with problems involving rates of change among variable quantities and employs a physical system representing numbers. Problems with as many as 18 variables can be solved.

The machine, which weighs 100 tons and contains thousands of electronic tubes, approximately 150 motors, nearly 200 miles of wires, and several thousand relays, has three chief distinctions: a capacity three times that of earlier devices, greater precision, and more flexibility. The operator need not be a mathematician, but a mathematician must prepare the problem for the perforated tape which indicates the method of solving it.

The instrument was developed by scientists including Doctor S. H. Caldwell (A '27) associate professor of electrical engineering at the institute and a director of the institute's analysis center, and Doctor Vannevar Bush (F '42) director of the Office of Scientific Research and Development and president of the Carnegie Institution of Washington, D. C. The new machine has been in operation since six months after Pearl Harbor. It has worked out range tables for the guns of the United States Navy as well as such other difficult problems as fire control and radar antenna design.

INSTITUTE ACTIVITIES

Official Nominees Announced for 1946–47

J. E. Housley, district power manager, Aluminum Company of America, Alcoa, Tenn., was nominated for the AIEE presidency for the year 1946–47 by the nominating committee at its meeting in New York, N. Y., January 22, 1946. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1946, are:

For Vice-Presidents

E. W. Davis, chief electrical engineer, Simplex Wire and Cable Company, Cambridge, Mass. (North Eastern District, number 1).

O. E. Buckley, president, Bell Telephone Laboratories, New York, N. Y. (New York City District, number 3).

T. G. LeClair, staff engineer, Commonwealth Edison Company, Chicago, Ill. (Great Lakes District, number 5).

R. F. Danner, general superintendent, Oklahoma Gas and Electric Company, Oklahoma City (South West District, number 7).

C. F. Terrell, vice-president, Puget Sound Power and Light Company, Seattle, Wash. (North West District, number 9).

For Directors

J. F. Fairman, vice-president, Consolidated Edison Company of New York, New York, N. Y.

R. T. Henry, chief electrical engineer, Buffalo (N. Y.) Niagara and Eastern Power Company.

E. P. Yerkes, engineer of equipment and buildings, General Electric Company, Philadelphia, Pa.

For Treasurer

W. I. Slichter, professor emeritus, electrical engineering, Columbia University, New York, N. Y.

The nominating committee, in accordance with the constitution and bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the board of directors from its own membership.

The constitution and bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the nominating committee. Provision is made for independent nominations as indicated in the following excerpts from the constitution and bylaws:

Constitution

Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District covered.

Bylaws

Section 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the Constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

BIOGRAPHICAL SKETCHES OF NOMINEES

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "Personal" columns of the March issue.

Winter Convention Report to Appear in March Issue

As this issue goes to press the Institute's 1946 winter convention gets under way at New York, N. Y. Early indications are that this convention is continuing the successful record of prewar years in spite of the inevitable effects of the war. Registration for the first two days totaled 1,681 compared with 1,059 for the first two days of the 1942 convention and with 1,278 for the similar period of the 1941 convention. The March issue of *Electrical Engineering* will contain the full report of the convention.

Summer Convention Planned to Be Outstanding

The various committees assigned to activities for the AIEE summer convention to be held in Detroit, Mich., June 24–28, 1946, with headquarters in the Hotel Statler, are effecting plans to make the meeting an outstanding event in the Institute's history. The removal of wartime restrictions will permit a return to normality, and there is promise that this convention will embrace many desirable features, which during the war, of necessity, were eliminated.

Under the direction of S. M. Dean (M '41) chairman, T. G. Glenn (M '38) vice-chairman, and W. F. Wetmore (M '43) secretary-treasurer, the following committee chairmen, with their respective committees are functioning to insure a long-remembered meeting.

M. A. Bergdahl	Hospitality
D. D. Chase	Sports
H. W. Collins	Hotels
A. J. Koetsier	Publicity
A. E. Kreigsmann	Meetings and papers
W. J. Piper	Information and transportation
V. J. Snyder	Finance
R. C. Spaulding	Inspection trips
F. R. Temple	Registration
(Mrs.) M. A. Bergdahl	Women's hospitality

Information on the scope and text of technical papers to be presented is not available at this date, but it can be assumed that this phase of the convention activities will maintain its position of importance to the electrical engineer and to the development of the art.

In addition to the president's reception, the hospitality and sports committees are planning a variety of entertainment including golf, tennis, boating, and smoker, for the men, and corresponding features for the women including bridge-dinner, and theater parties. Industrial inspection trips will be arranged, and trips are planned to historic Greenfield Village and other points of interest.

Planning Committee Hires Secretary

To expedite the work that it has undertaken in the study and evaluation of AIEE activities and professional relationships, the AIEE committee on planning and co-ordination secured the approval of the board of directors at its October 1945 meeting to establish a temporary full-time paid staff of one person to act as assistant secretary for the committee. Accordingly, in December the committee acquired the services of William H. Schlasman (A '25) who will devote his entire time to the committee's current project (*p. 86*).

A full report covering the 1946 winter convention conference sponsored by the committee on planning and co-ordination tentatively is scheduled for publication in the March issue of *Electrical Engineering*. The stated purpose of this conference was to accommodate the presentation of preliminary reports and tentative proposals drawn up by the committee and its subcommittees, and to provide opportunity for

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Future AIEE Meetings

South West District Meeting
San Antonio, Tex., April 16–18, 1946

North Eastern District Meeting
Buffalo, N. Y., April 24–26, 1946

Southern District Meeting
Asheville, N. C., May 14–16, 1946

Summer Convention
Detroit, Mich., June 24–28, 1946

Pacific Coast Convention
Seattle, Wash., in week of August 26–30, 1946

Great Lakes District Meeting
Fort Wayne, Ind., September 25–27, 1946

interested Section representatives and other AIEE members to participate directly in an open general discussion.

Vannevar Bush Receives 1946 Washington Award

Doctor Vannevar Bush (A '15, F '24) president of The Carnegie Institution of Washington (D. C.) and director, Office of Scientific Research and Development, has been elected the recipient of the Washington Award for 1946.

The Washington Award was established in 1916 by Past President Alvord of the Western Society of Engineers, Chicago, Ill., and is presented by the Washington Award Commission, composed of nine representatives of Western Society of Engineers and two each from American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and AIEE, to the engineer who has done some outstanding work or whose services in general have been directed toward promoting the public good. Presentation will be made at a joint dinner meeting of the participating societies February 20, 1946.

A biography of Doctor Bush is given elsewhere in this issue.

SECTION • • • • • •

E. P. Coles Honored By North Carolina Section

At the November 1945 meeting of the AIEE North Carolina Section resolutions of congratulation were tendered E. P. Coles (F '35) retired, upon his 50th year of affiliation with the Institute. Mr. Coles joined the Institute in 1895 while employed as a test man with the General Electric Company, Schenectady, N. Y. He is credited with outstanding work in the electrification of the textile industry in North Carolina and South Carolina, and with taking an important part in the development of the power industry in that section.

In its resolution, the Section expressed its gratitude to Mr. Coles for "the generous contribution of his time and ability throughout the life of the Section. . . ."

Sharon Section Observes 20th Anniversary of Founding

The 20th anniversary of the founding of the Sharon (Pa.) Section, AIEE, was observed December 11, 1945, in that city. Doctor Joseph Slepian (F '27) associate director of research, Westinghouse Electric Corporation, who spoke at the organization meeting in 1926 on "Power Flow in Electric Machinery" spoke also at the anniversary meeting on the topic, "Development of Atomic Energy." He confined his remarks to the use of atomic power for military purposes under the auspices of the United States Government. Preceding Doctor Slepian's address A. D. Forbes (M '42) chairman of the group, introduced W. M. Dann (F '26) first chairman of the organization, who gave a brief history of the formation of the Section.

It was in November 1925 that a group of local Sharon men petitioned the AIEE to organize a Section in Sharon. That petition was approved on December 11, 1925.

Boston Section Forms New Technical Group

The new technical group on instruments and measurements of the Boston Section, AIEE, formed in 1945, is the fifth technical group to be organized by that Section; the other groups are electric machinery, electronics, insulation, and power systems. Professor C. L. Dawes (F '35) associate professor of electrical engineering, Harvard University, Cambridge, is chairman of the new technical group. Meetings were held in April and October. Doctor G. S. Brown (A '33) associate professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, spoke on "Servomechanism Applications and Principles of Operation," December 4, 1945.

Scheduled for the year 1946 are talks by P. L. Bellaschi (F '40) development engineer, Westinghouse Electric Corporation, Sharon, Pa., on "Surge Generators and Their Contribution to Electrical Engineering" February 26, and L. H. Hutchins, Jr., Simplex Wire and Cable Company, on "Electrical Measurements in a Cable Factory," March 26.

DISTRICT • • • • •

South West, North Eastern District Meetings in April

Two AIEE District meetings will be held in April 1946. They are the South West District (7) meeting scheduled for April 16–18 in San Antonio, Tex., and the North Eastern District (1) meeting to be held in Buffalo, N. Y., April 24–26. Arrangements are being made for full programs of technical sessions which will include papers, entertainment, sports, and trips.

Details on the coverage of the technical papers are not yet available, but it is anticipated that this feature of the programs in both cities will measure up to its past record and will prove of inestimable value to electrical engineers in attendance. The full programs of papers and events will be published in subsequent issues of *Electrical Engineering*.

PERSONAL • • • •

Philip Sporn (A '20, M '26, F '30) executive vice-president, American Gas and Electric Service Corporation, New York, N. Y., has been awarded the Edison Medal for 1945 "for his contributions to the art of economical and dependable power generation and transmission." Mr. Sporn, who was born in Galicia in 1896, holds the degree of electrical engineer from Columbia University (1917). From 1917 to 1919 he was in the test department of the Crocker-Wheeler Electric Manufacturing Company, and in 1919 joined the staff of Consumers Power Company, Jackson, Mich., engaging in station and substation design work. He became associated with the American Gas and Electric Service Corporation in 1920 and has progressed through positions of protection engineer, communication engineer, transmission and distribution engineer, station engineer, chief electrical engineer, up to his present position of executive vice-president and chief engineer or director of 15 subsidiaries of the parent organization. In 1928 he won the AIEE national first prize in the field of engineering practice for his paper, "Rationalization of Transmission System Insulation Strength." He has been a consultant of the War Production Board and among other services, prepared a comprehensive report on the use of silver as a substitute for copper and aluminum as electrical conductors. He is a member of American Society of Mechanical Engineers, American Society of Civil Engineers, American Society for Testing Materials, Franklin Institute, and other societies. He has presented before the AIEE, associations, and in technical and economic journals a long list of engineering papers. He has been a member of many AIEE committees, including, power transmission and distribution, 1927–46, chairman 1941–43; award of Institute prizes, 1942–43; Standards, 1941–43, and Lamme Medal, 1944–47.

J. F. Fairman (A '20, F '35) formerly assistant vice-president, Consolidated Edison Company of New York (N. Y.), Inc., has been elected vice-president in charge of production and operation. Born in Big Rapids, Mich., Mr. Fairman was gradu-

Philip Sporn

ated from the University of Michigan with the degree of bachelor of science in electrical engineering (1918) and master of science (1921). There he served as instructor in electrical engineering from 1919 to 1922, and in the latter year was made assistant professor of electrical engineering. Three years later he joined the Brooklyn (N. Y.) Edison Company as assistant outside plant engineer and was made outside plant engineer and assistant electrical engineer (1926) and electrical engineer (1932) and following the merger of the various companies into the Consolidated Edison company he became electrical engineer for the system. On December 1, 1940, he was elected assistant vice-president for design, inventory, purchasing, and stores. Mr. Fairman is AIEE vice-president for the New York City District (3). He has been active in Section affairs, holding the offices of secretary, 1937–38, and chairman, 1940–41, as well as that of District secretary, 1937–38. He has served on many AIEE committees, including planning and co-ordination, of which he is chairman, 1945–46; technical program, 1945–46; executive, 1944–46; finance, 1944–46; board of examiners, 1941–44; education, 1941–42, and safety codes, 1931–34. Since 1938 he has been an AIEE representative on the Engineers' Council for Professional Development. He has served also on the electrical equipment committee of the Edison Electric Institute, and has held the office of president of the New York State Society of Professional Engineers.

Robin Beach (A '15, F '35) head of the department of electrical engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., resigned January 1, 1946, to devote his entire time to consulting engineering practice. Professor Beach was graduated from New Hampshire University with the degree of bachelor of science in electrical engineering in 1913 and received the degree of electrical engineer in 1922. In the latter year he received also a master-of-science degree in physics from New York University. Immediately upon graduation in 1913 Professor Beach began his teaching career which was to take him to the University of Illinois, Urbana; Texas Agricultural and Mechanical College, College Station; Norwich University, Northfield, Vt.; until in 1918 he became associate professor of electrical engineering at the Polytechnic Institute of Brooklyn. Later as acting head of the department he supervised the development of an electrical communications laboratory. In 1927 he was appointed professor of electrical engineering and in 1930 head of the department. Since 1932 he has been an associate in the consulting engineering firm of McCrossin and Company, New York, N. Y., handling the electrical aspects of the firm's work. In June 1944 he went on an extended leave of absence from Polytechnic Institute and in September 1944 organized his own consulting engineering firm of Robin Beach Associates, Brooklyn, to handle work growing out of war requirements in industry. He will continue with this enterprise and retain his association with McCrossin and Company. Professor Beach has been very active in Institute affairs, having served on numerous committees, such as production and application of light, education, technical program, Alfred Noble Prize, 1943–47, Lamme Medal, 1943–46, safety, 1944–46, board of examiners, 1941–42, 1945–46. At present he is a representative of the Institute on the United States national committee of the International Commission on Illumination, 1937–46.

Vannevar Bush (A '15, F '24) president, Carnegie Institution of Washington (D. C.) and director, Office of Scientific Research and Development, has been elected the recipient of the 1946 Washington Award. Doctor Bush, a native of Massachusetts, was graduated from Tufts College with the degrees of bachelor and master of science in 1913; he received honorary doctorates from that institution and from nine other leading colleges and universities. He has been honored with the Levy Medal of the Franklin Institute (1928), AIEE Lamme Medal (1935), Holley Medal of the American Society of Mechanical Engineers, and the John Scott Medal of the Philadelphia City Trustees (1943). Doctor Bush has been engaged in many enterprises —General Electric Company, Schenectady, N. Y., on the faculty of Tufts College (Mass.) as consulting engineer, American Radio and Research Corporation, Medford Hillside, Mass., and dean of engineering, Massachusetts Institute of Technology, Cambridge. He was elected president of the Carnegie Institution of Washington in 1939 and in 1940 the late President Roosevelt appointed him chairman of the National Defense Research Committee and director of the Office of Scientific Research and Development in 1941. His society affiliations include membership in the American Association for the Advancement of Science, American Physics Society, American Academy of Arts and Sciences, American Philosophical Society, American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. He has been very active in AIEE affairs, and has served on many committees including: Edison Medal, 1933–38; Lamme Medal, 1936–39, chairman, 1938–39; board of directors, 1937–41; education, 1928–29, and research, 1924-30 and 1939–41.

W. H. Schlasman (A '25) formerly with J. H. Bunnell and Company, Inc., New York, N. Y., has been appointed to a temporary position on the AIEE staff as assistant secretary for the committee on planning and co-ordination (see page 84). Mr. Schlasman was born in Reading, Pa., in 1897, and was graduated from Lehigh University (1920) with a degree in mechanical engineering and from Yale University (1926) with a master-of-science degree in electrical engineering. He joined the staff of the long lines department, American Telephone and Telegraph Company, New Haven, Conn., in 1920 and remained until 1926. From the latter year until 1932 he was associated with electrical research products division, Western Electric Company, New York. Subsequently Mr. Schlasman was for short periods with the American Newspaper Publishers Association, Federal Communications Commission, and the New York *Times* in the operation of facsimile transmission over telephone circuits. Following an association of nearly five years with Fidelity and Casualty Company, New York, Mr. Schlasman served as telephone engineer with the Army Signal Corps on Governors Island, N. Y. From the latter part of 1942 to December 1944 he was technical writer and then editor for Sperry Gyroscope Company, Brooklyn, N. Y. In December 1944 he joined Bunnell and Company, Inc., New York, and was appointed engineer in charge, specifications and publications.

V. B. Bagnall (M '38) formerly circuit layout engineer, long lines engineering department, American Telephone and Telegraph Company, New York, N. Y., and more recently colonel, Signal Corps, Army of the United States, has been released from active duty and has returned to his former company as division plant superintendent of the long lines for the territories of Maryland, Virginia, West Virginia, and the District of Columbia. Colonel Bagnall, who received a bachelor-of-science degree from the University of Wisconsin (1927), and a master-of-science degree from New York University (1933), first entered the employ of the telephone company in 1927 and was assigned to the long lines department, Chicago, Ill. A year later he was transferred to the long lines department in New York. In 1942 he was ordered to active duty with the Signal Corps as captain and later was promoted to major (1942), lieutenant colonel (1943), and colonel (1944). In December 1942 Colonel Bagnall was appointed chief, communications engineering branch, Army Communications Service, Office of the Chief Signal Officer. He was awarded the Bronze Star and the Legion of Merit.

E. I. Pollard (A '35, M '45) design engineer, a-c generator engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed to the engineering staff of the Ridgway plant of the Elliott Company, Jeannette, Pa. Mr. Pollard received a bachelor-of-science degree from the University of Nebraska (1929) and a master-of-science degree from the University of Pittsburgh (1935). He entered the employ of the Westinghouse company in 1928.

C. E. Parks (A '40) relay engineer, power department, Public Service Company of Indiana, Indianapolis, recently was elected president of the Indiana Engineering Council.

J. L. Dow (M '25) director of switching development, Bell Telephone Laboratories, Inc., New York, N. Y., retired in 1945 after a period of 38 years with the company. Following his graduation from the Kansas State Agricultural College in 1906 with a bachelor-of-science degree in electrical engineering, Mr. Dow went to Western Electric Company, Chicago, Ill., as an engineering student. Subsequently, he served for several years in Hawthorne, Ill., and in 1916 he took the position of circuit development engineer in New York. In 1925 he was put in charge of the circuit laboratory testing manual and machine switching telephone circuits of the Bell Telephone Laboratories. In 1921 he became laboratories engineer for the local systems department, and in 1943 he was named director of switching development.

F. J. Scudder (M '25) systems development engineer, has been appointed director of switching development. Mr. Scudder joined the New York Telephone Company in 1905 and five years later became associated with the dial telephone switching program of the Western Electric Company. In 1918 he became a member of the technical staff of Western Electric Company and the Bell Telephone Laboratories, Inc.

I. H. Osborne (A '05, M '38) chief electrical engineer, Federal Shipbuilding and Dry Dock Company, Kearny and Port Newark, N. J., retired December 31, 1945. Mr. Osborne, a native of Waterbury, Conn., studied electrical engineering at Pratt Institute. For two years he was with the General Electric Company at Lynn, Mass., and for 17 years was associated with the Newport News (Va.) Shipbuilding and Dry Dock Company, serving as draftsman, assistant electrical engineer and later acting electrical engineer. In 1919 he was made electrical engineer of the Federal Shipbuilding and Dry Dock Company. Mr. Osborne has served on the following AIEE committees: marine (applications to marine work and marine transportation), 1918–46, chairman, 1941–43; technical program, 1941–43, and Standards, 1941–43.

R. W. Erickson (M '20) assistant electrical engineer has been named chief electrical engineer. From 1907 to 1912 he served an apprenticeship with the Harlan and Hollingsworth Corporation, Wilmington, Del., and for the next two years was associated with E. I. du Pont de Nemours and Company, Wilmington. Subsequently he was employed at the Philadelphia (Pa.) Navy Yard, and then followed a period of nearly two years with the Sun Shipbuilding and Dry Dock Company, Chester, Pa. In 1917 he was appointed chief electrical draftsman and assistant to the electrical engineer for the Federal Shipbuilding Company. He directed the installation of the electric system in the Kearny yard.

P. R. Knapp (A '18, F '38) assistant general superintendent, Toledo (Ohio) Edison Company, has been promoted to general superintendent. Mr. Knapp was born in West Boylston, Mass., and was graduated from Worcester Polytechnic Institute (1917) with a bachelor-of-science degree in electrical engineering. He joined the Toledo Edison Company, then known as the Toledo Railways and Light Company in 1917, and after serving in World War I he rejoined the Toledo company in 1919. The next year he was placed in charge of construction planning and designing. Subsequently, he was appointed assistant superintendent of the electric distribution and transmission department and then superintendent. He held this position until 1943 when he was made assistant general superintendent. Mr. Knapp was a member of the AIEE committee on power transmission and distribution, 1942–43.

K. J. Affanasiev (M '41) who recently completed work with Columbia University's division of war research as research and project engineer with Airborne Instruments Laboratory, Mineola, N. Y., has joined the staff of the Federal Communications Commission as principal engineer. Mr. Affanasiev, a native of Russia, received a bachelor-of-science degree in electrical engineering (1932) and a master-of-science degree in electrical engineering (1935) from the University of Wisconsin. Early in his career he worked for the Pacific Telephone and Telegraph Company, in Seattle, Wash., and San Francisco, Calif., and later for the Wisconsin Public Service Commission. In 1935 he became associated with Federal Communications Commission and served as associate telephone engineer and telephone engineer. In 1939, as engineer, he undertook special studies for the Pennsylvania Water and Power Company, Baltimore, Md., and remained with that utility until he engaged in the war research program of Columbia University, New York, N. Y.

W. L. Cisler (M '35) formerly chief engineer of power plants, Detroit (Mich.) Edison Company, and more recently United States chief in charge of German utilities under the Allied Control Authority has resumed his former duties with the Detroit utility. During World War II he was associated with the Office of Production Management, Washington, D. C., and with the power section of the Office of War Utilities. He has served on the following AIEE committees: power generation, 1935–43, chairman, 1940–42, technical program, 1940–42, and Standards, 1941–42.

F. A. Fleming (M '43) who specializes in the supply and repair of scientific industrial instruments Ottawa, Ontario, Canada, has been appointed technical representative in Ottawa for R. H. Nichols, Toronto, Canadian agents for Cambridge Instruments, Evershed and Vignoles Limited, and Ernest Turner Instruments Limited, England.

L. H. Cleary (A '20, F '42) consulting engineer, Weschler and Cleary, Washington, D. C., was appointed to the new post of technical director, National Electrical Contractors Association, Washington, effective January 1, 1946. Mr. Cleary has a long record in the electrical contracting industry. His more recent assignments include the design of the electrical distribution system for the assembly and repair shop at the United States Marine Corps base at Quantico, Va., and the United States Signal Corps School Project, Arlington, Va. A native of Connecticut, Mr. Cleary received his bachelor-of-science degree in electrical engineering in 1916 from the engineering school of the Catholic University of America. At present he is serving as secretary-treasurer of the AIEE Washington Section. He also is a member of the Society of American Military Engineers and is treasurer of the National Society of Professional Engineers.

O. K. Coleman (M '37) has resigned as assistant to vice-president and as chief engineer of the American Gas and Electric Service Corporation, New York, N. Y., and has moved to Mexico, Ind., where he will look after his farming interests and engage in consulting work. He has been retained by the Duncan Electric Manufacturing Company, Lafayette, Ind., and will be available for that firm on field applications. In 1923 he joined the American Gas and Electric property and has served as meter superintendent, field meter engineer, and meter engineer. Mr. Coleman served as chairman of the Edison Electric Institute's committee on the revision of the National Electrical Metermen's Handbook. He assisted in bringing about the standardization of outdoor meter mountings and associated equipment.

G. A. Kelsall (A '10) member of the technical staff, Bell Telephone Laboratories, New York, N. Y., retired in 1945 after a 33-year service record with the company. Mr. Kelsall, a native of Louisville, Ky., was graduated from Rose Polytechnic Institute with the degree of bachelor of science in electrical engineering in 1906. Early in his career he was employed by Louisville Railway Company, General Electric Company, and Indiana Steel Company, Gary, Ind. In 1909 he went to Michigan Agricultural College, East Lansing, as an instructor in electrical engineering. Three years later he joined the Western Electric Company, New York. Beginning with 1917 his work was directed to fundamental studies of magnetic materials. He has investigated more than 2,500 alloys.

L. A. Buese (A '31) chief design engineer, Hawaiian Electric Company, Limited, Honolulu, Hawaii, has been appointed vice-president, executive engineer, and director. Mr. Buese early in his career served as electrician and foreman for the street railway in Bisbee, Ariz., and as electrician in Salt Lake City, Utah. In 1921 he became affiliated with the Los Angeles (Calif.) Gas and Electric Corporation and was lineman, assistant foreman, foreman, electrical protection engineer, and assistant superintendent of electrical distribution. Later he went to Honolulu and in 1938 served as electrical engineer, Hawaiian Electric Company. Subsequently he became design engineer and chief design engineer.

R. K. Honaman (A '16, F '36) formerly director, school for war training, Bell Telephone Laboratories, Inc., New York, N. Y., is now director of publication. In 1919 he became a member of the technical staff of the transmission development department, American Telephone and Telegraph Company, New York, and in 1934 was named protection methods engineer, Bell Telephone Laboratories, Inc. During World War I he was engaged in Washington, D. C., in studies relating to airplane engine design. In World War II he organized the school for war training for the laboratories and was its director until May 1945 when he was named assistant director of publication.

H. R. Anderson (A '27, M '36) formerly electrical engineer, system planning section, Bonneville Power Administration, Portland, Oreg., and a reserve officer, recently on active duty with the Engineer Corps, headquarters, Sixth Army, has returned to his former position. Mr. Anderson, who received a bachelor-of-science degree in electrical engineering from Iowa State in 1922, has been identified with the Great Western Power Company, San Francisco, Calif., Loup River Public Power District, Columbus, Nebr., and with the United States Engineers at the Fort Peck (Mont.) Dam. In 1938 he joined the staff of the Federal Power Commission, Washington, D. C.

A. A. Emlen (A '28) vice-president, American Transformer Company, Newark, N. J., is taking charge also of engineering and related activities of the company. A graduate of the University of California with a bachelor-of-science degree in electrical engineering, Mr. Emlen was associated first with the Western States Gas and Electric Company, Placerville, Calif., and then with the General Electric Company in Schenectady, N. Y., and Pittsfield, Mass. In 1927 he joined the engineering department of the American Transformer Company.

E. G. Eidam (A '18) consulting engineer and formerly chief telephone engineer, Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., retired January 1, 1946, after more than 40 years with the company. Mr. Eidam, was born in Blue Island, Ill., in 1879 and was graduated in mechanical engineering from the University of Illinois. In 1904 he joined the staff of the Stromberg-Carlson Telephone Manufacturing Company and was engaged first in the design and manufacture of electric apparatus. He rose to the positions of assistant chief engineer, chief telephone engineer, and in 1944 was made consulting engineer.

B. W. Creim (A '20, F '31) assistant chief engineer, Bonneville Power Administration, Portland, Oreg., recently was appointed regional power manager of the United States Bureau of Reclamation, Sacramento, Calif. Mr. Creim, a native of Chicago, Ill., attended George Washington University. After a short period with the United States Bureau of Standards, Washington, D. C., he joined the staff of the Bureau of Power and Light, City of Los Angeles, Calif., remaining in this assignment until 1927. In the latter year he took a position as chief electrical engineer with the Modesto (Calif.) Irrigation District, and in 1936 was appointed senior electrical engineer for the Rural Electrification Administration, Washington, D. C. In 1939 he was appointed principal engineer in charge of the project construction section, engineering division, Bonneville Dam project. Mr. Creim served recently with the United States Navy.

C. L. Sampson (A '25, M '39) assistant vice-president, Northwestern Bell Telephone Company, Omaha, Nebr., since July 1, 1944, has been promoted to general manager for the State of Iowa and has transferred to Des Moines, Iowa. A native of Minneapolis, Minn., Mr. Sampson was graduated from the University of Minnesota with the degrees of bachelor of science in electrical engineering (1923) and master of science in electrical engineering (1925). He was an instructor in electrical engineering at the University of Minnesota, Minneapolis, before becoming engineer of transmission, protection, and plant extension, Northwestern Bell Telephone Company for the Iowa area in 1928. In 1939 he was made plant engineer for Minnesota, leaving that position in 1940 to become chief engineer in Iowa.

L. E. Messinger (A '30, M '44) president and managing director, Canadian Line Materials, Limited, Toronto, Ontario, is also president, Selenium Corporation of Canada, following a recent appointment. Mr. Messinger served as electrical engineer of the Economy Fuse and Manufacturing Company, Chicago, Ill., just before World War I in which he was lieutenant, Engineer Corps, Army of the United States. After the war he returned to that company. In 1925 he became sales engineer, Line Material Company, Milwaukee, Wis., and in 1929 was made president and managing director, Canadian Line Materials, Limited, Scarboro Junction, Ontario.

R. A. Schatzel (A '28) formerly director of research, General Cable Corporation, Bayonne, N. J., is now vice-president and director of engineering, Rome (N. Y.) Cable Corporation. He first was employed in the research laboratory of the General Electric Company, Schenectady, N. Y., and in 1924 joined the Rome company to do research and development work. The next year he was made assistant director of research, and in 1927 he became technical director of the Rome wire division of the General Cable Corporation Mr. Schatzel returned recently from a visit to Germany where he was a member of a group of scientists sent to Europe for an investigation of German technology. During World War II Mr. Schatzel served as chairman of an industry-advisory committee of the War Production Board, and also as War Production Board representative on the war committee for dielectrics.

W. R. Herod (A '20) formerly executive vice-president, International General Electric Company, New York, N. Y., has been elected president and a director. Mr. Herod was graduated from the Sheffield Scientific School, Yale University, in 1918. He joined the General Electric Company, Schenectady, N. Y., in 1919 later serving as special assistant in the construction-engineering department. In 1929 he was transferred to the International General Electric Company. From 1934 to 1937 he was assistant to the managing director, Associated Electrical Industries, London, England, and in 1937 returned to New York as vice-president of International General Electric. Called to active service with the Army Air Forces in 1942 as a lieutenant colonel, he shortly was promoted to colonel and served with the Air Technical Service Command, Wright Field, Dayton, Ohio, and at Detroit, Mich. He was elected executive vice-president on his return to the company in 1945.

W. F. Lebo (A '20) formerly acting chief engineer, Public Service Commission of Indiana, Indianapolis, has been appointed chief engineer. Mr. Lebo was graduated from the school of electrical engineering, Purdue University. He worked for short periods for the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., and the Merchants Heat and Light Company, Indianapolis, before 1919 when he was named senior engineer for the commission. Mr. Lebo served on the legislative committee, AIEE Central Indiana Section, 1944–45.

C. A. Molsberry (A '29) formerly general superintendent of production, United Illuminating Company, New Haven and Bridgeport, Conn., has been appointed system planning engineer. **M. F. Beebe** (A '41) formerly superintendent of distribution, succeeds Mr. Molsberry. **W. J. Oakley** (A '43) assistant superintendent of distribution, New Haven division, has been named superintendent of distribution.

C. W. DeForest (A '07, F '36) who retired in 1945 after 43 years with the Columbia Engineering Corporation, New York, N. Y., and its affiliate, the Cincinnati (Ohio) Gas and Electric Company, now is serving as United States chief in charge of German utilities under the Allied Control Authority. Early in his career Mr. DeForest was associated with the Brooklyn (N. Y.) Edison Company, United Electric Light and Power Company, New York, and General Electric Company, Schenectady, N. Y. He was appointed vice-president of the Columbia Power Company in 1925 when that was formed as a subsidiary of the Columbia Gas and Electric Corporation, and later became chief engineer of the Columbia Engineering and Management Corporation, a company later abandoned. When in 1938 the Columbia Engineering Corporation was formed, he was given charge of the electrical division. At the the time of his retirement he was vice-president.

H. B. Bryans (M '17, F '18) executive vice-president, Philadelphia (Pa.) Electric Company, has been re-elected to serve a third term as president of the American Standards Association. **F. R. Lack** (M '37) vice-president and manager, radio division, Western Electric Company, Inc., New York, N. Y., was elected vice-president. **E. C. Crittenden** (A '19, F '44) assistant director, National Bureau of Standards, was made chairman of the Standards Council. **L. F. Adams** (A '09, F '42) assistant to the vice-president, General Electric Company, Schenectady, N. Y., was made vice-chairman of the Standards Council.

L. F. Eaton (A '45) formerly assistant general manager, Montaup Electric Company, Brockton, Mass., has been appointed manager of the Woonsocket (R. I.) division of the Blackstone Valley Gas and Electric Company. He had been associated with Brockton (Mass.) Edison Company and Stone and Webster Service Corporation. Before going to Woonsocket he served as assistant to the vice-president in charge of electric operations of the Blackstone Valley property in Pawtucket, R. I.

L. A. Gary (A '12, M '26) formerly exchange transmission engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif., retired October 1, 1945. Mr. Gary was born in Zanesville, Ohio, June 5, 1883, and was graduated from Case School of Applied Science in 1904 with a bachelor-of-science degree in electrical engineering. Mr. Gary first was employed by the San Francisco (Calif.) Gas and Electric Company, and from 1905 to 1911 by the Western Electric Company, San Francisco. For the next two years he was engaged in his own engineering and contracting business. In 1913 he went with the Pacific Telephone and Telegraph Company. For the past 20 years he has served in the transmission department.

C. V. Armstrong (A '36) formerly electrical engineering group, general engineering department, Standard Oil Development Company, Elizabeth, N. J., and more recently lieutenant, United States Coast Guard has been placed on inactive duty by the Coast Guard Reserve after spending three years on the design and test of ship's machinery, especially turbine-electric propulsion machinery. He now is engaged in research and development in electrochemical applications for Bell and Gossett Company, Morton Grove, Ill.

S. B. Lent (M '43) formerly assistant electrical engineer, Boston (Mass.) Elevated Railway, has been appointed electrical engineer. Mr. Lent became associated with the Boston Elevated Railway in 1922, later being placed in charge of the electrical engineering division laboratory. In 1938 he assumed the duties of engineer, and became a consultant to the rolling stock and shops department on all electrical problems.

R. A. Nielsen (M '45) formerly research engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named head of the company's new Pacific coast high-frequency laboratory, Los Angeles, Calif. Doctor Nielsen was born in Portland, Oreg., and was graduated from Stanford University as a bachelor of arts in 1933, a master of arts in 1934 and a doctor of philosophy in 1937, all degrees being awarded in physics. He is a member of the American Physical Society.

W. G. Ellis (A '23) formerly commander, United States Naval Reserve, has been released from active duty. He served in several capacities and more recently as assistant inspector of naval material for the Western Electric Company and the Bell Telephone Laboratories, New York, N. Y. He was commissioned lieutenant commander in 1942 and promoted to commander in 1943.

Olav Maseng (M '25) major, Army of the United States, has been cited for the Bronze Star Medal for "the successful discharge of those responsibilities which resulted in the restoration of electric plants and lines and solid fuels redevelopment in France and Belgium, and enabled those governments, as far as military necessity permitted, to discharge their responsibilities." Before entering military service Major Maseng was affiliated with the Square D Company, Detroit, Mich.

F. C. Bates (A '41) formerly maintenance engineer, production and transmission department, Utah Power and Light Company, Salt Lake City, is now with the Westinghouse Electric Corporation as electrical engineer in the engineering and service department at San Francisco, Calif. From 1942 to 1945 Mr. Bates served as a civilian engineer in the engineering branch of the headquarters, Ninth Service Command, United States Army.

W. G. H. Finch (A '22, M '26) has resumed the presidency of Finch Telecommunications, Inc., Passaic and Clifton, N. J., after having been released from active duty as captain, United States Naval Reserve. He was born in Birmingham, England, and has been associated with Allis-Chalmers Manufacturing Company, Norwood, Ohio, Cleveland (Ohio) Electric Illuminating Company, and Royal Indemnity Company, New York, N. Y. He also served the International News Service, New York, N. Y., as radio engineer.

D. C. Jackson (A '87, HM '44) professor emeritus of electrical engineering, Massachusetts Institute of Technology, Cambridge, has been awarded honorary membership in the American Society of Mechanical Engineers for leadership in education and consulting-engineering fields.

K. F. Bellows (A '30, M '38) formerly division engineer, system engineering department, Consolidated Edison Company, of New York, New York, N. Y., Inc., has joined McKinsey and Company management consultants, as a consultant in the firm's New York office.

A. J. Swank (M '43) assistant electrical engineer, has succeeded Mr. McKay as station construction engineer. Mr. Swank in 1919 became associated with the Pacific Gas and Electric Company. He has held the positions of construction foreman and construction superintendent.

E. L. Lotz (A '38, M '45) formerly research director, New Jersey Wood Finishing Company, Woodbridge, is now with the Owens-Corning Fiberglas Corporation, Toledo, Ohio.

E. R. Hoyle (A '20, M '37) formerly assistant to electrical engineer, Sinclair Refining Company, East Chicago, Ind., is now electrical engineer.

E. P. Nelson (A '27, M '45) since 1933 assistant electrical engineer, Electric Boat Company, Groton, Conn., is now consulting engineer, Elliott Company, Ridgway, Pa.

E. H. Aiken (A '29, M '37) formerly electrical engineer, Imperial (Calif.) Irrigation District, has joined the staff of the General Electric Company, Los Angeles, Calif.

G. A. Fowles (A '37) formerly manager, electric wire and cable insulating materials, has been made sales manager for Geon thermoplastics of the B. F. Goodrich Chemical Company, Cleveland, Ohio.

J. M. Livingston (A '30) formerly sales manager, Schweitzer and Conrad, Inc., Chicago, Ill., has opened his own electrical sales-engineering office in Chicago.

W. W. Parker (A '30, M '37) switchgear and control department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed regional engineer of the Rio de Janeiro (Brazil) office of the Westinghouse International Company.

Noel Pike (A '25, M '32) formerly superintendent of construction, Cia Impulsora de Empresas Electricas, Mexico, Federal District, Mexico, is now chief electrical engineer of the Imperial (Calif.) Irrigation District.

E. L. Harder (A '30, M '41) central-station engineer in the industry-engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has received the Order of Merit from his company.

V. T. Johnson (A '33) formerly of the research and records section, Los Angeles (Calif.) Bureau of Power and Light now is serving as chief of the operation division of the Rio de Janeiro (Brazil) Tramway, Light and Power Company's electric system.

C. R. Hanna (A '24, F '44) associate director of the research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been awarded the degree of doctor of engineering by Purdue University, Lafayette, Ind.

A. L. Maillard (M '23) superintendent, power and distribution, Military Chemical Works, Pittsburgh, Kan., has been appointed managing director of the Electric League of Indianapolis, Ind.

D. S. Jacobus (A '03) retired from Babcock and Wilcox Company of New York, N. Y., recently was made an honorary member by the American Welding Society.

OBITUARY

Bryson Dexter Horton (A '14) retired president, Square D Company, Detroit, Mich., died December 14, 1945. He was born in Fenton, Mich., September 28, 1871, and received a bachelor-of-science degree from the University of Michigan in 1895. For the first four years of his career he was electrical engineer, Public Lighting Company, Detroit, and then for a year served as electrical engineer for the Detroit Copper Mining, Morenci, Ariz. Subsequently he became general manager of the Detroit Fuse and Manufacturing Company. During the Spanish-American War he served as chief electrician of the USS *Yosemite.* In 1903 he founded the Square D Company and remained its president until 1928, the year of his retirement. Mr. Horton served for four years as advisor to the Public Works Administration, State of Michigan. He was a member of the board of directors of the Rackham Engineering Foundation, a corporation with title to the $500,000 endowment created by Horace H. Rackham and Mary A. Rackham Fund for the benefit of the engineering professions and allied arts and sciences in the Detroit area. He was a member of the board of governors of the Horace H. Rackham school of graduate studies, University of Michigan, and an honorary member of the Engineering Society of Detroit. He is credited with inventing the arcless enclosed fuse and electric safety switches.

Norman Graves Reinicker (M'18) formerly vice-president and general manager, Pennsylvania Power and Light Company, Allentown, Pa., died January 13, 1946. Mr. Reinicker was born in Baltimore, Md., November 13, 1889, and was graduated from Cornell University (1911) with the degree of mechanical engineer. In 1911 he went to work in the research and test department of the Detroit (Mich.) Edison Company and subsequently became boiler room engineer and assistant chief engineer. Then he became assistant to the chief engineer of the New York (N. Y.) Edison Company. After a short period as power superintendent, Du Pont Engineering Company, Nashville, Tenn., Mr. Reinicker became affiliated in 1919 with the Lehigh Valley Light and Power Company, Allentown, one of the predecessors of the Pennsylvania Power and Light Company, as superintendent of operations. When a few years later the Pennsylvania Power and Light Company was organized Mr. Reinicker became its superintendent of operations and later was made general superintendent and general manager. He was named vice-president and general manager in 1935. He was a former president of the Pennsylvania Electric Association and the Lehigh Valley Engineers' Club.

W. P. MacDonald (M '43) general manager, British Columbia Power Commission, Vancouver, Canada, died November 30, 1945. Mr. MacDonald was born in Sherbrooke, Quebec, Canada, January 3, 1892, and in 1910 went to work for the Bell Telephone Company in that city. After two years he became associated with the Alberta Government Telephone Department, Edmonton, remaining in this assignment also two years. For a year he was identified with the Burnham Frith Electric Company, and in 1917 became foreman in the meter department of the City of Edmonton Light and Power Department. There he remained until 1928 when he was made district superintendent of the Canadian Utilities, Limited, Calgary, and in 1931 he became manager, Nanaimo-Duncan Utilities, Limited, Nanaimo, Vancouver, prior to the time that power company was taken over by the British Columbia Power Commission. More recently he had been general manager for the Vancouver Island of the British Columbia Power Commission. He was active in the Canadian Electrical Association and also took an active part in the welfare and civic work in Nanaimo.

Leo B. Hedges (A '28, M '42) chief load dispatcher, Bureau of Power and Light, City of Los Angeles, Calif., died November 30, 1945. Mr. Hedges was born February 7, 1888, in Bloomington, Ill., and studied at the University of Illinois and the University of Southern California. Early in his career he was an apprentice wireman in Bloomington. From 1913, when he took the position of assistant electrician for the Los Angeles Aqueduct, until his death, he served that city in various capacities. With the Bureau of Power and Light he was electric crane operator (1915–17); power plant operator (1917–22); load dispatcher (1922–31); assistant chief load dispatcher (1931–39); and chief load dispatcher. In that latter assignment he was in charge of the new dispatching headquarters containing many advanced facilities which was placed in service in 1941.

C. H. Van Slyck (A '03) prior to his retirement five years ago vice-president and treasurer, Watson-Flagg Engineering Company, New York, N. Y., died in December 1945. Mr. Van Slyck was born in Schenectady, N. Y., and after leaving high school, spent three years in the students' course of the General Electric Company both at Schenectady and at Lynn, Mass. He worked also in the commercial department of the company. Early in his career he was superintendent of equipment of the Coney Island and Brooklyn Railroad, Brooklyn, N. Y., and shortly thereafter became identified with the Watson-Flagg Engineering Company which he served as secretary and treasurer, treasurer, and then vice-president and treasurer, the position he held at the time of retirement.

Henry Rutherford Gabay (A '07, M '30) retired, New York (N. Y.) Telephone Company, died January 12, 1946. Mr. Gabay was born in New York, June 14, 1876, and was graduated from Cornell University (1897) with a mechanical engineering degree in electrical engineering. He began his association with the New York Telephone Company in 1898 and served as housetop engineer, underground engineer, construction engineer, and in 1910 was made division commercial engineer. Later he was appointed division plant engineer (1912), commercial engineer (1913) and general commercial engineer (1920). He retired in 1941 after giving his services for 43 years to the company. As general commercial engineer Mr. Gabay became one of the country's authorities on telephone rates.

Frederick Dewey Jackson (M '42) associate professor of electrical engineering, University of New Hampshire, Durham, died December 18, 1945. Professor Jackson was born May 30, 1898, at Royersford, Pa., and was graduated from Pennsylvania State College with a bachelor-of-science degree (1920) and an electrical-engineer degree (1939). From 1921 to 1923 he was an instructor in the electrical engineering department of Cornell University, Ithaca, N. Y., and in the latter year became engineer in the radio engineering department of the General Electric Company, Schenectady, N. Y. In 1924 he took the position of instructor in the electrical engineering department of the University of New Hampshire and in 1927 was made assistant professor, and associate professor in 1939. In 1944 he left the university to serve the Bell Telephone Laboratories, Inc., New York, N. Y., as engineer in the transmission department. Late in 1945 he returned to the university.

Charles Langdon Perry (A '03) formerly electrical control devices designer, General Electric Company, Schenectady, N. Y., died November 20, 1945. Mr. Perry was born in Astoria, N. Y., July 19, 1875, and was graduated in electrical engineering, Columbia University in 1896. A few months after leaving college he joined the staff of the General Electric Company and was employed by that firm for his entire life. In the engineering department he served as designing engineer and later as electrical engineer. Subsequently he was made industrial control engineer and finally entered the electrical control devices design department.

MEMBERSHIP . . .

Recommended for Transfer

The board of examiners, at its meeting of January 17, 1946, recommended the following members for transfer to the grade of membership indicated. Any objections of these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Taylor, A. H., chief consultant and co-ordinator, Naval Research Laboratory, Washington, D. C.
Terrell, C. F., vice-president, Puget Sound Power & Light Co., Seattle, Wash.
Watkins, S. S., elec. engr., Gibbs & Hill, Inc., New York, N. Y.
West, C. P., mgr., switchboard engg., Westinghouse Electric Corp., E. Pittsburgh, Pa.

4 to grade of Fellow

To Grade of Member

Armstrong, C. V., Bell & Gossett Co., Morton Grove, Ill.
Brooke, H. L., sales mgr., Pacific Electric Mfg. Corp., San Francisco, Calif.
Brooks, J. D., utilities adviser, Federal Public Housing Authority, Washington, D. C.
Burkhart, J. R., proposition design engr., General Electric Co., Pittsfield, Mass.
Byrd, H. L., managing engr., pr. circuit breaker div., General Electric Co., Philadelphia, Pa.
Clagett, W. H., elec. engr., U. S. Bureau of Reclamation, Dept. of Interior, Coulee Dam, Wash.
Clark, E. N., Comdr., U. S. Navy, Decommissioning Section, San Francisco, Calif.
Clements, V. O., application engr., Westinghouse Electric Corp., Houston, Texas.
Cleveland, L. F., assoc. prof., elec. engg., Northeastern University, Boston, Mass.
Cottony, H. V., National Bureau of Standards, Washington, D. C.
Dix, W. H., asst. engr., Potomac Electric Power Co., Washington, D. C.
Endicott, H. S., elec. engr., General Electric Co., Pittsfield, Mass.
Fluke, J. M., Comdr., USNR, Bureau of Ships, Navy Dept., Washington, D. C.
Frank, C. W., asst. chief engr., Automatic Electric Co., Chicago, Ill.
Gregg, W. E., Jr., asst. to gen. mgr., Monitor Controller Co., Baltimore, Md.
Hatch, W. H., engr., Public Service Co. of Northern Ill., Chicago, Ill.
Heibel, J. D., mgr., condenser div., Erie Resistor Corp., Erie, Pa.
Hellmann, K., elec. engr., Philadelphia Navy Yard, Philadelphia, Pa.
Janowitz, A. W., sales engr., General Electric Co., Dayton, Ohio.
Keith, A. H., elec. engr., Consolidated Vultee Aircraft Corp., San Diego, Calif.
Killian, S. C., chief engr., Delta Star Electric Co., Chicago, Ill.
Lippert, G. D., elec. engg. dept., American Gas & Electric Service Corp., New York, N. Y.
Lloyd, T. C., chief engr., Robbins & Myers, Inc., Springfield, Ohio.
Meldrim, E. T., supt. of substations, Pacific Gas & Electric Co., Oakland, Calif.
Overgaard, H., elec. squad leader, Ebasco Services, Inc., New York, N. Y.
Page, E. R., instructor, University of Oklahoma, Norman, Okla.
Peters, C. S., elec. engr., Rural Electrification Administration, St. Louis, Mo.
Riner, W. B., engr., Army Service Forces, Air Technical Service Command, Wright Field, Dayton, Ohio.
Rudd, H. H., vice-pres., Railway & Industrial Engg. Co., Greensburg, Pa.
Salati, O. M., senior engr., Hazeltine Electronics Corp., Little Neck, N. Y.
Shelton, E. E., instructor, elec. engg., Cooper Union, New York, N. Y.
Sitkin, A., elec. engr., Voorhees, Walker, Foley & Smith, New York, N. Y.
Stanley, W. M., asst. construction supt., Tennessee Valley Authority, Wilson Dam Branch, Sheffield, Ala.
Theriault, G. I. F., equip. engr., Frigidaire Div., General Motors Corp., Dayton, Ohio.
Wickham, W. H., engr., testing dept., Commonwealth Edison Co., Chicago, Ill.
Yost, J., director, Vose Memorial Laboratory, Great Neck, L. I., N. Y.

36 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before March 15, 1946, or May 15, 1946, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Colton, R. B., Maj. Gen., USA, Army Air Forces, Washington, D. C.

1 to grade of Fellow

To Grade of Member

Adams, R. T., The Ambos-Jones Co., Cleveland, Ohio
Anderson, R. B., The Grampian Electricity Supply Co., Perth, Scotland
Bartlett, G. S., Public Service Co. of Northern Illinois, Northbrook, Ill.
Bartlett, S. C., American Gas & Electric Service Corp., New York, N. Y.
Basil, A. S., United States Rubber Co., New York, N. Y.
Byrnes, T F., Cutler Hammer, Inc., Milwaukee, Wis.
Cain, E. S., Scaife Co., Oakmont, Pa.
Callaham, P. R., Abbott Laboratories, North Chicago, Ill.
Carruth, J. A., Gulf States Utilities Co., Lake Charles, La.
Chambliss, L. M., The Commonwealth & Southern Corp., Birmingham, Ala.
Collier, D. F., Westinghouse Elec. Supply Co., Boston, Mass.
Cyphert, D. W., 11th Naval Dist. Public Works, San Diego, Calif.
Fairfield, R. M., British Insulated Callender's Cables, Ltd., London, England
Frederick, C. L., Cornell Aeronautical Lab., Buffalo, N. Y.
Fyfe, R., The Grampian Electricity Supply Co., Perth, Scotland
Garside, B. H., Britannic Electric Cable & Construction Co. Ltd., Iver, Buckinghamshire, England
Greene, F. R., Stockwell Transformer Corp., Akron, Ohio
Hale, S. G., Bell Telephone Labs., Inc., New York, N. Y.
Harper, W. E., Davis Transformer Co., Concord, N. H.
Heberlein, G. E., Railway & Industrial Engineering Co., Greensburg, Pa.
Heinlein, R. I., Jr., Lt. Col., U. S. Military Academy, West Point, N. Y.
Hilbert, E. W., N. Y. Telephone Co., New York, N. Y.
Hill, L. R., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Honnell, P. M., Lt. Col., Signal Corps, West Point, N. Y.
Kinghorn, J. H., American Gas & Electric Service Corp., New York, N. Y.
Kraepelien, H. Y., Ericsson Telephone Sales Corp., New York, N. Y.
Krezdorn, R. R., University of Texas, Austin, Tex.
Landmeier, E. W., Wadsworth Electric Mfg. Co., Inc., Covington, Ky.
Leiter, K. S., Capt., Signal Corps, AUS, Peoria, Ill.
Ma, G. C. K., Metropolitan-Vickers Elect. Co., Ltd., Manchester, England
McDaniel, G. H., American Gas & Electric Service Corp., New York, N. Y.
O'Connor, J. P., Westinghouse Elec. Corp., Boston, Mass.
Pulsford, J. A., Public Service Electric & Gas Co., Newark, N. J.
Rao, D. S., M. E. S., Hospital Town East, Bangalore, India
Richard, W. J., General Cable Corp., New York, N. Y.
Rose, H. A., Westinghouse Electric Corp., Seattle, Wash.
Schaelchlin, W. (Re-election), Westinghouse Elec. Corp., East Pittsburgh, Pa.
Schramm, R. F., Arthur G. McKee Co., Cleveland, Ohio
Siler, A. E., North American Aviation, Inglewood, Calif.
Slack, R. C., American Gas & Elec. Serv. Corp., New York, N. Y.
Thoen, R., Farrel Birmingham Co. Inc., Buffalo, N. Y.
Thompson, W. W., Thompson Engineered Lighting Co., Boston, Mass.
Tsai, C-N, National Resources Comm., Washington, D. C.
Turner, E. M., Erie Resistor Corp., Erie, Pa.
Watkins, W. S., Ohio Rubber Co., Willoughby, Ohio
Westby, H. W., Tennessee Valley Authority, Knoxville, Tenn.
Williams, H. I., Burlington Electric Light Dept., Burlington, Vt.
Woodworth, C. O., Schockett Elec. Co., Denver, Colo.
Wright, J. T., Rural Electrification Administration, Madison, Wis.
Zeller, C. J., Consolidated Edison Co., New York, N. Y.

50 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Booth, C. E., Westcott & Mapes, New Haven, Conn.
Brandow, L. L., New York State Electric & Gas Corp., Binghamton, N. Y.
Clarkson, C. W., Jr., Corning Glass Works, Corning, N. Y.
Hall, H. W., Cambridge Elec. Light Co., Cambridge, Mass.
Horn, J. R., Boston Naval Shipyard, Cambridge, Mass.
Hunsicker, F. P., Westinghouse Electric Corp., Boston, Mass.
Hurley, R. J., United Illuminating Co., New Haven, Conn.
Ironside, D. S., Stromberg Carlson Tel. Co., Rochester, N. Y.
Jankowski, H., General Elec. Co., Schenectady, N. Y.
King, L. A., Jackson and Moreland, Boston, Mass.
Levitsky, F. J., Worcester Polytechnic Inst., Worcester, Mass.
Manzi, A. P., Manzi Electrical Co., Lawrence, Mass.
Murphy, M. D., United Illuminating Co., English Station, New Haven, Conn.
Ottalagana, J. S., Stromberg-Carlson Co., Rochester, N. Y.
Pickering, C. B., Jr., Allen-Bradley Co., Boston, Mass.
Quimby, R. B. (Re-election), General Electric Co., Schenectady, N. Y.
Smith, N. T., General Electric Co., Pittsfield, Mass.
Stellato, J. R., Dept. of Public Works, Albany, N. Y.
Tholstrup, H. L. (Re-election), International Business Machines Corp., Rochester, N. Y.
Webb, L. M., Hartford Electric Light Co., Hartford, Conn.
Wilder, W. D., Buffalo Niagara Electric Corp., Buffalo, N. Y.

2. Middle Eastern

Ballowe, J. C., Charleston Electrical Supply Co., Inc., Charleston, W. Va.
Barry, L. T., Electric Service Mfg. Co., Philadelphia, Pa.
Bartlett, D., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Bidle, C. P., Ohio Crankshaft Co., Cleveland, Ohio
Bindschadler, E., Westinghouse Electric Corp., East Pittsburgh, Pa.
Bodenstein, B. E., Brown Instrument Co., Philadelphia, Pa.
Campbell, R. E., Keystone Shipping Co., Philadelphia, Pa.
Crooker, P. R., Line Material Co. of Pennsylvania, East Stroudsburg, Pa.
Currens, C., Jr., Bethlehem Steel Co., Baltimore, Md.
Dickinson, W. E., Maj., Wright Field, Dayton, Ohio
Dotson, C. E., Jr., American Tel. & Tel. Co., Dayton, Ohio
Edgell, E. E., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Fischer, G. H. (Re-election), Middle Dept. Association of Fire Underwriters, Philadelphia, Pa.
Forrest, E. F. (Re-election), General Electric Co., Philadelphia, Pa.
Furfari, F. A., Westinghouse Elec. Corp., Cleveland, Ohio
Grimm, W. L., Jr., The Johns Hopkins Univ., Baltimore, Md.

Grynkewich, N. E., General Electric Co., Baltimore, Md.
Hammerquist, R. C., United Engineers & Constructors, Inc., Philadelphia, Pa.
Harris, A. G., Bethlehem Steel Co., Baltimore, Md.
Hess, W. J., 302 Morrison Bldg., Charleston, W. Va.
Hull, R. E., Westinghouse Electric Corp., Pittsburgh, Pa.
Huseby, S. B., E. I. DuPont DeNemours & Co., Inc., Belle, W. Va.
Johnson, B. W., Kanawha Valley Power Co., Charleston, W. Va.
Kingsley, H. D., General Elec. Co., Baltimore, Md.
Lehmkuhl, H. F., Frigidaire Division of G.M.C., Dayton, Ohio
Leinberger, F. A., General Electric Co., Philadelphia, Pa.
Marsteller, R. Z., Philadelphia Electric Co., Norristown, Pa.
McCollin, J. C., Capt., British Army Staff, Washington, D. C.
Mikell, S. H., Edison Light and Power Co., York, Pa.
Mirsch, J. W., General Electric Co., Baltimore, Md.
Myers, P. E., National Cash Register Co., Dayton, Ohio
O'Leary, C. J., Western Electric Co., Baltimore, Md.
Ramey, R. L., Ens., USNR, Middletown, Ohio
Reed, F. J., Philadelphia Electric Co., Philadelphia, Pa.
Reese, F. D., Pennsylvania Telephone Corp., Erie, Pa.
Richards, A. T., Westinghouse Electric Corp., Sharon, Pa.
Rottman, W. J., The Hoover Co., North Canton, Ohio
Runk, R. H., Westinghouse Electric Corp., East Pittsburgh, Pa.
Schulman, E. L., Westinghouse Electric Corp., East Pittsburgh, Pa.
Shoup, R. W., Insulation Manufacturers Corp., Cleveland, Ohio
Soos, S. W., Jr., Lake Shore Elect. Mfg. Corp., Cleveland, Ohio
Stafford, B. H., Naval Research Laboratory, Washington, D. C.
Stauffer, P. H., Westinghouse Electric Corp., Akron, Ohio
Stuffer, N., Westinghouse Electric Corp., Cleveland, Ohio
Tippy, G. F., General Elec. Co., Dayton, Ohio
Underhill, B. B., Penn. State College, State College, Pa.
Vidal, N. F., Pennsylvania Power Co., Sharon, Pa.
Warren, R. E., Westinghouse Elec. Corp., Toledo, Ohio
White, E. A., Naval Research Lab., Washington, D. C.
Wiatt, F. E. (re-election), Cincinnati Gas & Electric Co., Cincinnati, Ohio

3. NEW YORK CITY

Alpert, N., Republic Aviation Corp., Farmingdale, L. I., N. Y.
Arkus, H., Hazeltine Corp., Little Neck, L. I., N. Y.
Balacki, S. J., Newark Signal Corps Inspection Zone, Newark, N. J.
Barrett, E. M., Long Island Lighting Co., Mineola, N. Y.
Bergen, A. R., Lt., Sig. C., AUS, Ft. Monmouth, N. J.
Bierman, M., Underwriters' Laboratories, Inc., New York, N. Y.
Christ, G. J., N. Y. Telephone Co., Brooklyn, N. Y.
Clark, J. B., Electric Storage Battery Co., New York, N. Y.
Foote, C. L., Gibbs & Hill, Inc., New York, N. Y.
Goetz, D. F., Ens., USNR, Staten Island, N. Y.
Grissler, H. W., Public Service Electric & Gas Co., Newark, N. J.
Hutloff, E. W., Public Service Elec. & Gas Co., Newark, N. J.
Jamison, D. S., U. S. Naval Shipyard, Brooklyn, N. Y.
Karlskind, D. B., U. S. Rubber Co., New York, N. Y.
Lothes, R. N., Lt. Army Signal Corps, Fort Monmouth, N. J.
Mandell, A., 315 West 86th St., New York, N. Y.
Pope, C. A., General Cable Co., Perth Amboy, N. J.
Rich, F. N., 315 West 98th Street, New York, N. Y.
Sokol, W. J., The M. W. Kellogg Co., New York, N. Y.
Stack, J. B., Field Prod. Div., U. S. Naval Shipyard, New York, N. Y.
Sussman, H., Hazeltine Corp., Little Neck, N. Y.
Wang, S., National Resource Comm. of China, New York, N. Y.
Wiener, B. S., 1212 Newkirk Ave., Brooklyn, N. Y.

4. SOUTHERN

Albritton, L. E., Hq. Fourth Service Command, Atlanta, Ga.
Bishop, L., Tenn. Eastman Corp., CEW, Oak Ridge, Tenn.
Chalkley, M. H., Jr., Virginia Electric & Power Co., South Boston, Va.
Cheek, C. C., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Cooper, R· J. (Re-election), Georgia Power Co., Atlanta, Ga.
Darden, T. N., General Electric Co., Atlanta, Ga.
Davenport, T. O., Tenn. Eastman Corp., CEW Oak Ridge, Tenn.
Dorr, W .F., U. S. Maritime Comm., c/o N. C. Shipbuilding Co., Wilmington, N. C.
Flournoy, L. C., Alabama Power Co., Birmingham, Ala.
Green, F. B., Green Electric Co., Columbia, S. C.
Helfrich, R. B., General Elec. Supply Co., Norfolk, Va.
Henley, R. D., Tenn. Eastman Corp., Oak Ridge, Tenn.
Hollins, F. G., Southern Bell Tel. & Tel. Co., New Orleans, La.
Jacobsen, W. E., Comstock & Bryant Companies, Knoxville, Tenn.
Kirkland, H. G., Florida Power Corp., St. Petersburg, Fla.
LeBlanc, R. E.,III, Lt. (jg), U. S. Navy, New Orleans, La.
McGraw, L. A., General Elec. Co., Birmingham, Ala.
Molbert, J. J., Cities Service Refining Corporation, Lake Charles, La.
Rolufs, F. M., John McNeese Junior College, Lake Charles, La.
Saunders, R. K., 66 Norwood Circle, Birmingham, Ala.
Shaver, E. E., North Carolina Shipbuilding (USMC), Wilmington, N. C.
Simmons, D. W., Southern Bell Tel. & Tel. Co., Greenville, Miss.
Smith, R. T., Tennessee Valley Authority, Chattanooga, Tenn.
Smull, M. P., The Commonwealth & Southern Corp., Birmingham, Ala.
Strassmeyer, A. H., Kellex Corp., Oak Ridge, Tenn.
Tribble, W. F., Duke Power Co., Charlotte, N. C.
Trischman, C. A., Virginia Electric & Power Co., South Boston, Va.
Tuck, D. R., Virginia Electric & Power Co., South Boston, Va.
Turner, W. C., Alabama Power Co., Birmingham, Ala.
Vickrey, H. H., The Commonwealth & Southern Corp., Birmingham, Ala.
Williams, N. F., The Commonwealth & Southern Corp., Birmingham, Ala.
Zara, F., Georgia Power Co., Atlanta, Ga.

5. GREAT LAKES

Balzer, H. W., Automatic Electric Co., Chicago, Ill.
Bossman, L. J., A.C. Spark Plug, Flint, Mich.
Bracken, J. F., Commonwealth Edison Co., Chicago, Ill.
Brubaker, J. L., Western Electric Co., Chicago, Ill.
Cawson, W. F. (Re-election), Public Service Co. of No. Ill., Chicago, Ill.
Clark, F. S., The Milwaukee Elec. Ry. & Transport Co., Milwaukee, Wis.
Concha, D., Allis Chalmers Mfg. Co. (I.T.A.), West Allis, Wis.
Cress, W. M. (Re-election), Public Service Co. of No. Ill., Glencoe, Ill.
Detuno, R. J., Western Electric Co., Chicago, Ill.
Deuscher, R. E., Kuhlman Electric Co., Bay City, Mich.
Diefenbach, A. E., A.C. Spark Plug Div., Flint, Mich.
Fash, R. A., Aluminum Ore Co., E. St. Louis, Ill.
Gale, H. E., Western Electric Co., Inc., Chicago, Ill.
Gamble, M. E., P. R. Mallory & Co., Indianapolis, Ind.
Gassner, F., Bruce Cumming & Associates, Chicago, Ill.
Ghormley, R. K., Automatic Electric Co., Chicago, Ill.
Hall, R. C., Commonwealth Edison Co., Chicago, Ill.
Hammel, A. E., Allis Chalmers Manufacturing Co., Milwaukee, Wis.
Hauck, A. J., Surges Electric Co., Milwaukee, Wis.
Hoffman, J. R., Illinois Power Co., Belleville, Ill.
Horn, A. B., General Electric Co., Chicago, Ill.
Jackson, C. E., Paranite Wire & Cable Corp., Jonesboro, Ind.
Jacobson, L.; G-M Laboratories, Inc., Chicago, Ill.
Kelley, H. E., Dow Chemical Co., Midland, Mich.
Kollinger, H. F., Kuhlman Electric Co., Bay City, Mich.
Lane, M. G., Iowa Ordnance Plant, Burlington, Iowa
Maddox, R. D., Belden Manufacturing Co., Richmond, Ind.
Meece, H. C., Aluminum Company of America, Chicago, Ill.
Miller, L. H., Jr., Commonwealth Edison Co., Chicago, Ill.
Muir, D. W., Automatic Electric Co., Chicago, Ill.
Parker, E., General Motors Corp., Detroit, Mich.
Rose, W. H., Public Service Co. of Nor. Ill., Chicago, Ill.
Standifird, G. B., Sargent and Lundy Engineers, Chicago, Ill.
Swierczak, P. C., General Motors, Delco Remy Div., Anderson, Ind.
Swigart, H. E., Western Electric, Chicago, Ill.
Tanyolac, N. N., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Weed, L. A., AC Spark Plug Div., GMC, Flint, Mich.
Weyrauch, J. R., Public Service Co. of Nor. Ill., Chicago, Ill.
Wheeler, R. M., AC Spark Plug Div., GMC, Flint, Mich.
Wilson, T. J., Minneapolis Honeywell Regulator Co., Minneapolis, Minn.

6. NORTH CENTRAL

Brand, O. H., Nebraska Public Power System, Omaha, Nebr.
Hankins, R. E., M.S.T. & T. Co., Denver, Colo.
Roadhouse, C. S., Nebraska Power Co., Omaha, Nebr.

7. SOUTH WEST

Barrett, J. H., 2635 Park St., Beaumont, Tex.
Bryant, J. H., P. O. Box 151, Clyde, Tex.
Clyne, W. E., Federal Communications Commission Beaumont, Tex.
Cottom, M. C., University of Kansas, Lawrence, Kan.
Dyer, R. D., Tuco Plant, Abernathy, Tex.
Farnsworth, B. W., Lt., Signal Corps, Salina, Kan.
Hasty, C. M., Lower Colorado River Authority, Austin, Tex.
Hercher, W. D., Arkansas Power & Light Co., Pine Bluff, Ark.
Ingraham, C. W., Sangamo Elec. Co. of Springfield, Ill., Forth Worth, Tex.
Large, R. E., Southwestern Bell Tel. Co., Tulsa, Okla.
Larson, C. A. (Re-election), St. Joseph Light and Power Co., St. Joseph, Mo.
Lebow, B. I., Kansas Gas & Electric Co., Wichita, Kan.
Miller, A. G., 426 Dwight Bldg., Kansas City, Mo.
Price, R. T., Southwestern Public Service Co., Amarillo, Tex.
Sather, R. O., Maj., A.A.F., Roswell, N. Mex.
Shawver, E. F., Southwestern Bell Telephone Co., Houston, Tex.
Spence, W., Gulf States Utilities Co., Beaumont, Tex.
Walker, L. B. (Re-election), Lower Colorado River Authority, Austin, Tex.
Wheeler, D. B., Texas Electric Service Co., Fort Worth, Tex.
Woolsey, L. S., Marion L. Crist & Associates, Engr., Little Rock, Ark.
Yelderman, G. R., General Electric Co., Dallas, Tex.
Young, V. R., Graybar Electric Co., Dallas, Tex.

8. PACIFIC

Benson, A. R., North American Aviation, Inc., Inglewood, Calif.
Burns, A. E., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Caton, D. H., San Diego Gas and Electric Co., San Diego, Calif.
Clark, A. G., U. S. Post Office, Los Angeles, Calif.
Daly, G. M., 1140 E St., Eureka, Calif.
Dehrer, L. G., U. S. Navy, Mare Island, Vallejo, Calif.
Delano, F. X., E.M.2/c, U. S. Naval Training Center, San Diego, Calif.
Denholm, D. A., Southern Calif. Edison Co., Ltd., Alhambra, Calif.
Eaton, R. A., San Francisco Naval Ship Yard, San Francisco, Calif.
Engel, R. L., Allis-Chalmers Mfg. Co., Los Angeles, Calif.
Fitch, H. R., War Department, McClellan Field, Calif.
Grauer, C. T., Univ. of Calif., Berkeley, Calif.
Jessen, O. C., Department of Water and Power, Los Angeles, Calif.
Lowerison, C., Southern Calif. Edison Co., Los Angeles, Calif.
Odell, F. C., C. F. Braun & Co., Alhambra, Calif.
Overholser, P. H., So. Calif. Edison Co., Los Angeles, Calif.
Potter, W. T., Jr., So. Calif. Telephone Co., Los Angeles, Calif.
Sainsbury, T. R., San Francisco Naval Shipyard, San Francisco, Calif.
Schomberg, H. J., California Electric Power Co., Riverside, Calif.
Smith, C. L., Pacific Gas and Electric Co., Fresno, Calif.
Swift, F. T., Southern Calif. Telephone Co., Los Angeles, Calif.
Tarbell, R. J., San Diego Gas and Electric Co., San Diego, Calif.
Wood, C. L., Kaiser Co., Inc., Richmond, Calif.

9. NORTH WEST

Elggren, J. E., Utah Power & Light Co., Salt Lake City, Utah
Irwin, R. A., Lt., USNR, U.S. Naval Shipyard, Bremerton, Wash.
Moses, D., GE Supply Corp., Spokane, Wash.
Parsons, C. B. (Re-election), C. B. Parsons & Co., Seattle, Wash.
Perason, J. S., Utah Copper Co., Magna, Utah
Reese, W. P., Utah Copper Co., Arthur, Utah
Rose, N. L., General Electric Co., Tacoma, Wash.
Thomas, K. W., Westinghouse Elec. Corp., Spokane, Wash.

10. CANADA

Edson, R. E., Canadian General Electric Co., Montreal, Que., Can.
Morris, R. M., Nat. Research Council, Ottawa, Ont., Canada

Elsewhere

Adams, G. F., Messrs. Coverly Kendall, Lincolnshire, England
Ahmed, M., P.W.D., Anantagiri, Vikarabad, India
David, J. C., Central P.W.D., Simla, India
Miao, S. Y., Chungking Power Co., Chungking, China
Mukerjee, M. N., British Insulated Callender's Cables Ltd., Fort Bombay, India
Roden, A. H., General Electric Co., Ltd., Birmingham, England
Streuli, W. R. (Re-election), Brown Boveri & Co. Ltd., Baden, Switzerland

Total to grade of Associate
United States and Canada, 224
Elsewhere, 7

OF CURRENT INTEREST

Handbooks Issued on Wiring Design

Rudiments of the planning of electric wiring for the farmstead and for the single-family dwelling are covered in two pamphlets recently published and now available for distribution by the Industry Committee on Interior Wiring Design, Room 2650, 420 Lexington Avenue, New York 17, N. Y. The committee personnel includes representatives of appropriate branches of electrical industry. The project as a whole has been sponsored jointly by: American Institute of Electrical Engineers, American Home Lighting Institute, American Society of Agricultural Engineers, Edison Electric Institute, Illuminating Engineering Society, International Association of Electrical Inspectors, National Electrical Contractors Association, National Electrical Manufacturers Association, National Electrical Wholesalers Association, and Radio Manufacturers Association.

The purpose of these pamphlets is definitely not to explain how to install electric wiring, but rather to provide a comprehensive and standardized guide to the planning of electric wiring. According to the committee, it is the purpose of these pamphlets "to establish a list of recommendations, compliance with which will result in an efficient and convenient wiring system giving adequacy for present and anticipated future needs," and to "help avoid electrical obsolescence."

"Handbook of Farmstead Wiring Design" is a 54-page pamphlet specifically intended to help agricultural colleges, electric utilities, architects, engineers, builders, electrical contractors, lending institutions, sellers, buyers, and the farmer. It is illustrated generously with sketches and diagrams. Under the heading "Interior Wiring Design of Farmstead Buildings," the 16 sections cover such topics as definitions; branch and feeder circuits; dairy, poultry, beef cattle, horse, sheep, and hog structures; field, fruit, and vegetable crops; farm shops; water supply; farm residence; service equipment. Under the heading "Electrical Distribution (Exterior) for Farmstead Buildings" the seven sections include planning and definitions; pole, outdoor, and indoor metering; exterior lighting; tables and reference data. Price, 40 cents per single copy.

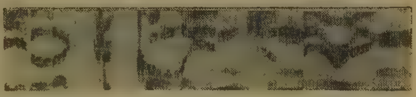
"Handbook of Residential Wiring Design" for single-family dwellings is a 26-page pamphlet specifically "designed to be of help to architects, engineers, builders, electrical contractors, lending institutions, sellers, buyers, and home owners." The pamphlet is illustrated generously with charts and layout diagrams. In addition to giving electrical symbols, general requirements, definitions, and a tabular summary of required outlets, the subject matter covers specific outlet requirements for all the various types of rooms; feeder and branch circuit requirements, and special requirements to accommodate signal and communication, radio and television, and telephone.

The committee now is turning its attention toward the preparation of similar handbooks for multifamily dwellings, and for commercial and industrial buildings.

"Visible Speech" Experiments by Bell Telephone Laboratories

A device which transforms sounds into patterns on a screen so that observers can see at a glance the character of the sound, whether it be speech, music, or noise, was demonstrated recently by Bell Telephone Laboratories, Inc., New York, N. Y.

The apparatus makes use of the fact that speech is defined fully by three quantities—pitch, loudness, and time. Sound at any instant can be analyzed by separating it into a suitable number of pitch groups, and measuring the intensity in each group. When this separating and measuring process is continuous, and the results are exhibited on a moving screen, patterns are formed which to a trained eye reveal not only the words spoken, but also the dialect of the speaker.



The sound of "Electrical Engineering" made visible at Bell Telephone Laboratories

It is expected that this experiment in "visible speech" eventually will equip the deaf person with a vocabulary of patterns as extensive as he is willing to acquire. But more than this it will convey factors of timing and emphasis which carry much of the emotional content of speech.

Two types of visible-speech instruments were shown at the demonstration. One, which made permanent records, consists of a loop of magnetic tape on which the sound was recorded by the usual technique. This loop was driven through the reproducer at the same rate as a paper-covered drum was rotated. The tape was played back repeatedly and a variable filter was tuned to a different pitch for each repetition. These filters separated out the sounds of various pitches and the intensity of the filtered current controlled the blackening of successive strips around the drum. Another instrument presents a running portrayal of speech. In this the output of each of several filters is brought to one of a series of glow lamps in a vertical row. Passing through the field of light from the row of lamps is an endless belt coated with phosphorescent material. As each lamp brightens and dims, a stream of light trails along the belt and so paints the patterns of visible speech. Passing out of sight, the pattern is erased by infrared illumination to leave a clean surface for new patterns. A variant of this method is one which employs a special form of cathode-ray tube. The beam of electrons sweeps vertically, while the sensitized surface revolves.

The Bell Laboratories states that the new apparatus is still in its early stage of development and in addition, any prospective users, of course, would require considerable instruction.

Mobile Radiotelephone Service Trial by Bell System

Plans for service trials of mobile radiotelephone service along three intercity highway routes totaling nearly 1,000 miles were announced recently by the Bell Telephone Laboratories, Inc., New York, N. Y. The routes are those between Chicago and St. Louis, via Ottawa, Peoria, and Springfield, Ill., between New York, Albany, and Buffalo, and between New York and Boston. Transmitting and receiving stations required to provide the two-way voice communication service will be located along the routes.

Calls will be handled by mobile-service telephone operators. The conversations will travel part of the way by telephone wire and part by radio. The occupant of a mobile unit will be able to originate calls merely by picking up his telephone, listening to make sure the circuit is not in use, and pushing the "talk" button. This will signal the mobile service operator and she will "come in on the line," take the call, and put it through in normal fashion.

Plans for the system's mobile radiotelephone service on intercity routes are extensions of plans announced previously for urban mobile service. Progress already has been made in the program for establishing radiotelephone stations in certain cities to provide local service to vehicles, including trucks, cars, and boats within or around those localities.

Applications for authorization to establish the first stations to serve the Chicago–St. Louis route already have been filed with the Federal Communications Commission by the Illinois Bell Telephone Company. Operation of the new service will not begin until several months after the Commission authorizes construction.

Radio Relay System Between Chicago and Milwaukee

A series of microwave radio-relay stations designed to handle television, sound radio programs, or long distance telephone calls, is to be constructed between Chicago, Ill., and Milwaukee, Wis., according to a recent announcement of the American Telephone and Telegraph Company. The long-lines department of the company filed applications December 11, 1945, with the Federal Communications Commission for authority to build and operate this super-high-frequency radio relay system on an experimental basis. The cost is estimated at $500,000.

The terminals for the system will be at the Illinois Bell Telephone Company long-distance center in Chicago and at the Wisconsin Telephone Company's toll building in Milwaukee. There will be three radio repeater stations along the way, about 25 miles apart—one near Barrington, Ill., another near Wilmot, Wis., and the third in the vicinity of Prospect, Wis. Along this particular route the terrain is fairly level, so that station antenna towers about 12 feet in height will insure sufficient clearance for the straight-traveling microwaves. A building will be erected at the foot of each tower to house the power and other equipment needed.

"Compiling Industrial Injury Rates." The completion of a new American Standard on the method of compiling industrial injury rates has been announced by the American Standards Association, New York, N. Y. This code provides a practical basis for recording and measuring industrial injury experience. In order that the resulting records may have a uniform experience basis covering the entire country, the provisions are independent of state and Federal requirements for reporting injuries for workmen's compensation and of rulings on disability by workmen's compensation agencies. To facilitate interpretations of the rulings in this Standard provisions have been made for an interpretations committee so that uniform handling of questionable cases may be used.

INDUSTRY • • • • •

Carrier Phones on REA Lines. Test installations of carrier telephone equipment have been made jointly by the Southwestern Bell Telephone Company, St. Louis, Mo., and the Rural Electrification Administration on the power lines of the Craighead Electric Co-operative Corporation, Jonesboro, Ark. In the new system, speech is transmitted by means of a carrier wave of radio-frequency. Appropriate transmitting and receiving equipment is installed at the switchboard and at the subscriber's end of the line. Dial instrument is used.

Cash Prizes for Papers on Welding. Cash prizes totaling $2,000 will be awarded in 1946 by the Resistance Welder Manufacturers' Association, Cleveland, Ohio, for outstanding papers dealing with resistance welding subjects. The contest is open to anyone, without restriction, from the United States and its possessions and Canada, and to any member of the American Welding Society. Awards will be made at the 1946 fall meeting of the American Welding Society.

OTHER SOCIETIES •

Radio Pioneers Hold Dinner

The radio pioneers' dinner of the New York section of the Institute of Radio Engineers was held in New York, N. Y., November 8, 1945, with more than 800 members and guests present. A brief historical note on the founding of the Institute of Radio Engineers in 1912 through merging the Wireless Institute of New York and the Society of Wireless Telegraph Engineers of Boston, Mass., was given by John V. L. Hogan (A '11, M '24). He pointed out that many of the reasons given to encourage the establishment of the Wireless Institute are still pertinent and as evidence quoted "radio will be developed faster if those engaged in it will work together more" which was contained in a letter written in 1909 by R. H. Marriott (A '06, F '26) to some 200 persons who, it was thought, might be interested in setting up a radio society.

Louis G. Pacent (M '18, F '30) president, Pacent Engineering Corporation, New York, served as chairman of the committee responsible for the dinner, and W. L. Everitt (A '25, F '36) president of the Institute of Radio Engineers, was master of ceremonies.

Chicago Show and Conference. "Production for Profit" will be the theme of the Chicago (Ill.) Production Show to be staged March 20–22, 1946, at the Stevens Hotel by the Chicago Technical Societies Council representing 46 scientific, engineering, and technological societies. The results of wartime advances in production tools, materials, handling devices, control instruments, and factory equipment in general will be on display for the community whose "Production for Victory" now yields to "Production for Profit." Manufacturers desiring information should get in touch with Paul A. Jenkins, execu-

A 28-kw magnet designed and built at Westinghouse Research Laboratories is expected to develop a maximum field of 40,000 gausses between the pole pieces spaced one-half inch apart and attracted to each other with a pull of two tons. Positioned between the magnet pole pieces is a magnetic field measuring device called a generating flux meter by its designer. A constant-speed motor turns a small coil in the field to be measured. In this picture the position of the flux meter is being adjusted between the pole pieces.

tive secretary, Chicago Technical Societies Council, 53 West Jackson Boulevard, Chicago.

Canadian Electrical Manufacturers Meet. The first annual meeting of the Canadian Electrical Manufacturers Association was held at Niagara Falls, N. Y., October 24–25, 1945, with an attendance of more than 200. M. P. Murphy, vice-president, Amalgamated Electric Corporation, Limited, was chosen the new president to succeed A. B. Cooper (F '33), president, Ferranti Electric Limited. Vice-presidents elected were the following: A. S. McCordick (M '30), vice-president, Moloney Electric Company of Canada, Limited; J. S. Keenan, manager, supply department, Canadian General Electric Company, Limited; and L. F. A. Mitchell, manager of sales, Canadian Westinghouse Company, Limited.

New Officers of AIME Elected

The American Institute of Mining and Metallurgical Engineers has elected the following officers for the year 1946: president, L. S. Cates, president of Phelps Dodge Corporation, New York, N. Y.; vice-presidents and directors, H. J. Brown, consulting engineer, West Newton, Mass., and E. V. Daveler, vice-president of American Zinc, Lead and Smelting Company, New York. Six other directors of the AIME were elected also by letter ballot of members.

Future Meetings of Other Societies

American Association for the Advancement of Science. March 27–29, 1946, St. Louis, Mo.

American Chemical Society. National Chemical Exposition. September 10–14, 1946, Chicago, Ill.

American Society for Testing Materials. Forty-ninth annual meeting. June 24–28, 1946, Buffalo, N. Y.

American Society of Tool Engineers. Exposition. April 8–12, 1946, Cleveland, Ohio.

Illuminating Engineering Society. National convention. September 18–21, 1946, Quebec, Quebec, Canada.

Instrument Society of America. Exhibit and conference. September 16–20, 1946, Pittsburgh, Pa.

National Association of Corrosion Engineers. Annual meeting and convention. May 7–9, 1946, Kansas City, Mo.

National Electrical Manufacturers Association. First international lighting exposition. April 25–30, 1946, Chicago, Ill.

Pennsylvania Electric Association. Spring meeting. May 28–29, 1946, Harrisburg, Pa.

Radio Manufacturers Association. Trade show. May 13–16, 1946, Chicago, Ill.

Society of Plastics Industry. First national plastics exposition. April 22–27, 1946, New York, N. Y.

Midwest Power Conference in Chicago

After a year's lapse due to the war, the Midwest Power Conference under the sponsorship of Illinois Institute of Technology will be held at the Palmer House, Chicago, Ill., April 3–5, 1946. Co-operating with the Illinois Institute of Technology in the sponsorship of the conference are nine midwestern colleges and universities and several engineering societies, among the latter the AIEE Chicago Section.

Preliminary plans include a session on the gas turbine and papers on industrial power plants, central-station practice, insulation problems on power systems, and recent electrical developments.

S. E. Winston, recently appointed director of the evening division at Illinois Institute of Technology, is director of the conference. Assisting him as conference secretary will be C. A. Nash (A '12) associate professor of electrical engineering at Illinois Institute.

ASCE Officers Elected for 1946

W. W. Horner, St. Louis (Mo.) consulting engineer, has been elected president of the American Society of Civil Engineers for 1946. Vice-presidents elected are: Arthur W. Harrington, district engineer, United States Geological Survey, Albany, N. Y., and J. T. L. McNew, vice-president for engineering, Agricultural and Mechanical College of Texas, College Station. Both the vice-presidents are past directors of the society.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Name Suggested for Insulated Conductor

To the Editor:

In Tracy D. Waring's letter, which appeared in the October issue of *Electrical Engineering*, page 381, the suggestion is made that the word "icon" should be adopted to apply to an insulated conductor.

Unfortunately this word has already been used for an entirely different purpose. An icon is "an image or representation" of a saint or divinity, for example, and is so defined in Webster's dictionary, as well as in other languages.

Sorry to be an iconoclast, Mr. Waring, but won't you try again?

PAUL MacGAHAN (A'02, F '42)

(Consulting electrical engineer, Woodstock, N. Y.)

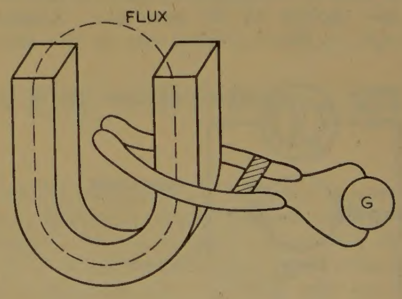
Electrical Essays for Recreation

To the Editor:

"No student would have any difficulty in recognizing what is wrong if our schools would cease to explain the law of electromagnetic induction by having a conductor 'cut' magnetic lines, but would adhere strictly to the fundamental concept that a voltage is induced when the flux associated with a loop is changing," writes Walter Richter in a letter to the editor (*EE, Oct '45, p. 381*).

Mr. Richter's plea for abandonment of the "cutting of-lines-of-force" theory of electromagnetic induction brings to mind some interesting electrical paradoxes presented for discussion by Carl Hering, AIEE president in 1901, more than 30 years ago. As I remember it, he described one of his experiments as follows:

> Two metal springs are mounted on an insulating block around one leg of a horseshoe magnet with the outer ends of the springs connected to a galvanometer as shown in Figure 1.



When the springs are pulled to the right a closed loop is maintained as the ends of the springs slide over the leg of the horseshoe magnet. If the springs are pulled far enough to become free of the magnet, the flux within the closed loop will drop to zero, and yet no deflection would appear on the galvanometer, indicating that no voltage has been induced.

In this case there is a sudden change of flux interlinked with a closed loop, but there is no cutting of flux by a conductor and there is no voltage induced. Doctor Hering, therefore, pleaded for a modification of Maxwell's law $e = N\frac{d\phi}{dt}$ so as to include actual cutting of flux in some way—in other words, just the opposite of the Richter recommendation.

Incidentally, correct reasoning from "cutting-of-flux" theory would have avoided the erroneous conclusion in the Richter illustration. The question is, "what kind of voltage is induced in the winding of an alternator when the field is excited with alternating current varying synchronously with the speed of the alternator?" The single-phase alternating field can be resolved into two components revolving in opposite directions. The velocity of the backwardly rotating field is neutralized by the mechanical rotation, becomes stationary in space, and induces no voltage. The velocity of the forwardly rotating field is added to the mechanical rotation and the resultant will induce a voltage of double frequency in the alternator winding. It was a misapplication of the "cutting-of-flux" theory which led to an erroneous deduction.

K. L. HANSEN (F '34)

(Consulting electrical engineer, Milwaukee, Wis.)

Glow Tube Motor Monitor

To the Editor:

The "negative-glow lamp," or glow lamp as it is called more frequently, can be used conveniently as a general purpose d-c motor monitoring instrument. Ferree[1] discussed characteristics and applications of this type of lamp, but did not present this interesting and useful application.

The glow lamp, when properly connected, will indicate direction of armature rotation, approximate speed of rotation, blocked armature conditions, and uneven running. The simplest application is that of a rotation direction indicator for a d-c motor. Figure 1 illustrates how the lamp should be connected for this purpose. D-c motor rotation reversal normally is accomplished by reversing the polarity of the voltage applied to the armature. Accordingly, in Figure 1 either one or the other electrode will glow, the glow emanating from the negative electrode, or cathode, as explained by Ferree, when the armature voltage is applied. The glowing electrode is thus an indication of the armature voltage polarity and consequently the direction of armature rotation. This information in turn is translated readily into motion specified as "right" or "left," "up–down" or "in–out" in some system operated by the motor. As shown in Figure 1, the right-hand electrode will glow if the reversing switch is in the "down" position.

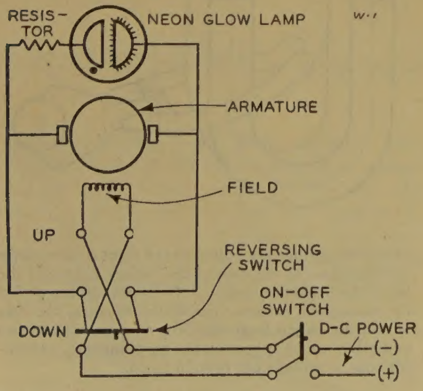


Figure 1. Method to indicate direction of d-c motor rotation

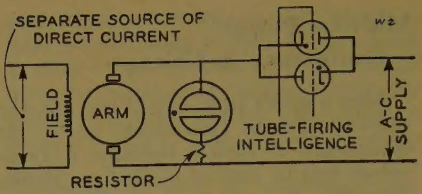


Figure 2. Back-to-back thyratron connection for motor reversing to show direction of rotation

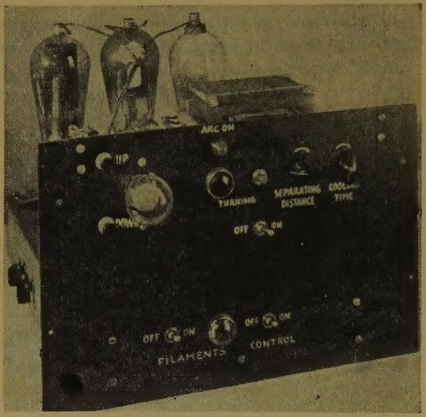


Figure 3. Controller to position arc electrodes

Lamp indicates direction of movable electrode

In many electronically controlled d-c motor applications, the motor is operated by thyratrons connected "back to back" as illustrated in Figure 2, with control grid intelligence determining which thyratron fires, for selection of rotation direction. A glow tube connected as shown will indicate rotation direction as previously described, by either one or the other electrode glowing. In case of control grid failure resulting in both thyratrons firing at one time, the glow tube will signal this undesirable situation by both electrodes glowing brightly. If only one tube is firing, as desired, but the armature is blocked, then the appropriate electrode will glow brightly as usual, but the other electrode, instead of being dark, will glow faintly. This is because the blocked rotor represents an inductive load, and the half-wave pulse of current produces a high reverse voltage "kick" as the applied alternating voltage reverses in polarity and forces the current to zero.

When series resistance is used to control armature speed, then the intensity of the glow in the glow tube will be a fairly good qualitative indication of speed, if the lamp is connected directly across the armature. The greater the speed, the brighter will be the glow. If the rotor is blocked, or the speed drops below a value corresponding to armature voltage being equal to glow voltage, the tube will not fire. If speed is controlled by phase shift of the grid voltage of the tubes (Figure 2), the intensity of glow again will give an indication of speed. This control will produce glow tube indications down to lower speeds than those available with rheostatic control, because the instantaneous voltage across the armature, even when the tubes are "phased back" for slow speed, may be enough to fire the glow tube for a short portion of the cycle.

A pulsating load, with corresponding hunting of the motor, will be characterized by a flicker in the glow tube when rheostatic speed control is used, or when a poorly regulated power supply is employed with a "back to back" electron tube connection.

Figure 3 shows a neon glow lamp, used as a d-c motor monitor, mounted in the panel face of an electronic controller that operates positioning motors for electrodes in arc apparatus. The lamp indicates whether the electrode rods are moving apart or together, corresponding to up–down motion of the lower electrode rod. The lamp also indicates the lower rod reaching the bottom of its travel by the upper electrode glowing faintly. In normal operation the controller is mounted in a large operating panel board so that only the indicating lamps are visible.

REFERENCE

1. Some Characteristics and Applications of Negative-Glow Lamp, H. M. Ferree. AIEE *Transactions*, volume 60, 1941, January section, pages 8–11.

VICTOR WOUK (A '43)

(Westinghouse Electric Corporation, East Pittsburgh, Pa., now with North American Philips Company, Dobbs Ferry, N. Y.)

25th Anniversary of Radiobroadcasting

To the Editor:

I think you missed a point of interest in not identifying the announcer of KDKA in the picture on page 366 of the October 1945 issue of *Electrical Engineering*. He is Noah C. Pearcy (F '43) divisional engineer, Public Utility Engineering and Service Corporation, Chicago, Ill.

At the time of that picture he was taking a postgraduate course under B. G. Lamme with Westinghouse Electric and Manufacturing Company and announcing for KDKA in his spare time, announcing being a spare-time job in those days. The picture in the magazine is poor and no one without the necessary background would be able to identify him. I have letterheads on which this picture was used and in which the features are much plainer.

Noah and I were high-school mates and

later roommates at Gary, Ind., where we both were benchboard operators for the power plant of the United States Steel Company. We were "ham" operators in 1911 using spark-coil transmitters and electrolytic detectors. Later we built a vacuum-tube receiver and got music from Doctor Conrad's station at Gary in 1920.

I believe that Noah's one-leg stand in the picture was the result of his running over an automobile on the way to the studio, trying to get there in time to make a "scheduled broadcast." He was quite bruised but like a good trooper, his motto was, "the show must go on."

HARRY PEET, JR. (A '27)

(President, Kentucky Edison Company, Stanton, Ky.)

Impedances of Synchronous Machines

To the Editor:

A number of papers have been presented recently on the impedances of synchronous machines, principally along the lines of refinements in theory and methods of measurement. Useful as such efforts may be, it is more in order probably to re-survey the field of usefulness for such constants, principally the subtransient and transient, and to some extent the synchronous reactances.

The AIEE committee on synchronous machines has issued one report[1] and a revision[2] which constitute a beginning in the setting up of utilization Standards. There seems to be some tendency, which the committee probably does not share, to regard those standards as complete and final. The writer wishes to make some specific objections to statements about those Standards, but first to sketch a survey of the whole field.

Power system computations in which impedances of synchronous machines are used fall into three general groups:

1. The stress group. This includes computations of magnetic stresses on busses and other current carrying gear, interrupting duty of breakers (particularly the higher speed types), and the requirements for fuses and protector tubes, including the d-c components of current to be interrupted.
2. The relaying group.
3. The loading group, including stability under disturbances.

The demarkations between groups are not definite, as high-speed relays may be akin to fuses. Similarly, transient stability cannot neglect relays and conversely.

When Messrs. Hanna, Travers, Wagner, Woodrow, and Skeats published their paper, "System Short Circuit Currents,"[3] the writer contributed a discussion[4] relating to short-circuit currents as they affect relays. As the title of the paper was general this discussion was not out of order, but it may not have been too appropriate, as the original paper, like the standards which grew out of it, relates primarily to the stress group. Actually there is no particular reason for going from stress figures to relay figures, except that the stress standards are the first in the field, and some may consider the subject to be closed thereby.

The writer's specific objections as raised in the discussion were: The paper took no account of certain (rather rare) transient phenomena, and was of no help in determining current values appreciably after the start of the fault. In regard to the latter, the present writer recommended the use of the internal voltage method when that amount of precision can be justified, otherwise, to use transient reactance and voltage behind it.

The committee on Standards took cognizance of relays, other than high-speed, by recommending the use of transient reactance with unit voltage behind it, and omitted mention of saturation effects. The writer's own technique is to use transient or subtransient reactances on a d-c calculating desk, with a loaded network. That is, prior to the fault the net reactive load on each bus is represented by a drain through a load resistor. The appropriate average machine internal voltage (1.19 for system maximum and transient reactances) is applied. The writer does not suggest this as a Standard, but does believe that short-circuit current problems, as related to relays, are worth discussion and possibly standardization apart from stress current figures.

The writer believes that the AIEE report,[1] as revised,[2] is quite a large and helpful step, particularly as regards the tabulations it includes, but wishes to offer objections to some of the statements in the text. We read as follows:

> The 3-phase short-circuit current is E/X_1. The line-to-line short-circuit current is $\sqrt{3}E/(X_1+X_2)$. Since X_2 is usually equal to or greater than X_1, this current seldom exceeds 86 per cent of the 3-phase short-circuit current, and consequently, for line-to-line faults the 3-phase fault-current value is generally satisfactory.

Some qualification besides the word "generally" in the afore-mentioned explanation should be used. *Generally*, it is true, but with respect to currents some time after the fault, there is much less decrement for phase-to-phase faults than for three phase, so that after an interval the phase-to-phase fault-current value may exceed the value for three phase at the same interval. If not a total but a branch current is in question, it may even exceed the initial 3-phase value for that branch.

We also read:

> The line-to-ground short-circuit current is $3E/(X_1+X_2+X_0)$. Since usually X_2 is equal approximately to X_1 (using the subtransient value for X_1), this expression is often shortened to $3E(2X_1+X_0)$. In practical cases regardless of the value of X_2, this last expression is satisfactory for determining the current in a double-line-to-ground fault.

This last sentence tends to give a definitely wrong impression, even though it may be true in many cases. It, with the previous sentence, tends to indicate that the relation of X_2 to X_1 is the important factor. Actually, however, the equivalent setup calls for paralleling X_2 with X_0 in series with X_1, and applying E to the combination, to obtain the sequence components from which phase conductor currents and ground currents can be derived. Therefore, the relation (in magnitude and phase angle) of X_2 with respect to X_0, determines whether the ground current for a double fault to ground is more or less than for a single line to ground fault. With impedance grounded neutrals, the double fault may give much less ground current than for a single line fault, but if the neutrals are grounded solidly and the fault is located so that the resultant X_0 is low, the ground current may exceed considerably that indicated. A recommendation in a Standard should not close the door to these possible exceptions.

It is necessary at this point to draw a distinction, which the Standards do not do, between the currents in the "hot" or phase equipment and those in neutral connections and gear, or those in grounding equipment. For double faults to ground, the ground current is made up of components from two phase leads, giving entirely different stresses to gear in the ground or neutral path.

In the second paragraph under "Procedure" it is said that either E/X_1 or $3E/(2X_1+X_0)$ will give "the highest value of rms symmetrical current for any type of fault." The foregoing discussions indicate that this is not always true, particularly for subdivisions of currents in branches, and is subject to exceptions in the ground and neutral paths, as stated, for double line to ground faults.

May we hope for further work in this field in the near future, including the consideration of saturation effects for example, and particularly in regard to relay applications.

REFERENCES

1. Simplified Calculation of Fault Currents. Report sponsored by AIEE committee on protective devices. *Electrical Engineering*, volume 61, 1942, pages 509–11, and AIEE *Transactions*, volume 61, 1942, pages 1133–5.

2. AIEE *Transactions*, volume 63, 1944, February section, pages 65–8.

3. AIEE *Transactions*, volume 60, 1941, September section, pages 877–81.

4. AIEE *Transactions*, volume 60, 1941, pages 1351–3.

GEORGE W. HAMPE (M '44)

(Engineer, testing department, Commonwealth Edison Company, Chicago, Ill.)

NEW BOOKS • • •

"ASTM Standards on Electrical Insulating Materials (with related information)." This compilation prepared by the ASTM committee D-9 gives in their latest form the more than 75 widely used specifications and test methods covering electrical insulating materials and related products. The committee is a working group under the ASA committee C-59 which is sponsored by ASTM and on which AIEE is represented by R. W. Atkinson (F '28) chief research engineer, General Cable Corporation, Bayonne, N. J., Doctor W. B. Kouwenhoven (F '34) dean, school of engineering, Johns Hopkins University, Baltimore, Md., and H. W. Bousman (M '36) general engineering laboratory, General Electric Company, Schenectady, N. Y. Included also are several reports covering the significance of tests of insulating materials, a proposed method of testing askarels, and most recent recommendations affecting standards on electrical insulating materials. The reports discussing the tests cover dielectric strength, impact, tensile strength, power factor, resistivity, and for insulating liquids several others such as viscosity. American Society for Testing Materials, Philadelphia, Pa., 1945. 560 pages, 6 by 9 inches, paper, $3.25.

"Electronics for Engineers." This is a collection of 142 articles, reference sheets, charts, and graphs for design engineers, builders, and users of electronic equipment and component parts, reprinted in convenient and economical form from the pages of *Electronics*. Individual papers have been grouped into chapters for convenient reference to make the book practically self-indexing. The articles cover 27 subjects, including antennas, audio amplifiers, capacitors, cathode-ray tubes, and electronic heating. Edited by John Markus and Vin Zeluff. McGraw-Hill Book Company, Inc., New York and London, 1945. 390 pages, $6.

"Electronic Engineering Master Index" (first annual edition). This is a definitive guide to the radio-electronic engineering literature published during the past two decades. Part 1 covers the period from January 1925 to December 1934; part II, the period from January 1935 to June 1945. This compilation contains approximately 15,000 entries, the majority of which are the titles of all engineering articles that have appeared in the leading professional periodicals and engineering periodicals in aeronautical, chemical, mechanical, and general industrial fields. Edited by Frank A. Petraglia. Electronics Research Publishing Company, New York, N. Y., 1945, cloth, 318 pages, $17.50.

LIBRARY • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MAKING PATENT DRAWINGS. By H. Radzinsky. The Macmillan Company, New York, N. Y., 1945. 96 pages, 10¼ by 7¼ inches, cloth, $3. Explicit instructions are given for shading, placement of numerals and figures, and other special techniques in making drawings both for patents and for trade-marks.

INDUSTRIAL PLASTICS. Third edition (revised). By H. R. Simonds. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1945. 396 pages, 9¼ by 6 inches, linen, $5. Important new developments and processes are covered and a chapter is devoted to foreign practice. Design information suggestions for new applications and markets, and a revised trade-name index provide further useful material.

CHEMICAL FORMULARY. Volume 7. Edited by H. Bennett. Chemical Publishing Co., Brooklyn, N. Y., 1945. 474 pages, tables, 9 by 5½ inches, cloth, $6. Some 2,000 formulas are presented in this latest volume of a series. As with the rest of the series, none of the formulas has appeared in previous volumes. There is a list of sources of chemicals and supplies not readily available.

HISTORY OF PHOTOGRAPHY. By J. M. Eder, translated by E. Epstean. Columbia University Press, New York, N. Y., 1945. 860 pages, tables, 9¼ by 6 inches, cloth, $10. This comprehensive historical treatise is a translation of the fourth edition, 1932, of the original German work, and carries through the first quarter of the 20th century. It begins with an examination of the rudimentary knowledge of light and its properties held by the ancient Greeks and Romans and proceeds, century by century, through the discoveries and contributions of individuals from many nations.

MARINE ELECTRIC POWER. By Q. B. Newman. Third edition, Simmons-Boardman Publishing Corp., New York, N. Y., 1945. 244 pages, diagrams, charts, tables, 7¾ by 4¾ inches, cloth, $2.50. Avoiding the use of advanced mathematics and physics, this elementary text covers the essentials of electrical theory, the principles of electrical engineering, and the use of electric equipment on shipboard.

MEANING OF RELATIVITY. By A. Einstein. Princeton University Press, Princeton, N. J., 1945. 135 pages, diagrams, charts, tables, 8 by 5½ inches, cloth, $2.00. This is a reissue of Mr. Einstein's classic presentation of his theory of relativity. It is intended for the general reader who has some understanding of modern physics and advanced mathematics. The subject of space and time in prerelativity physics is discussed as well as the special and general relativity theories. An appendix, covering significant advances in this field since 1921, has been included in this new edition.

PLASTICS. Third edition. By J. H. DuBois. American Technical Society, Chicago, Ill., 1945. 447 pages, illustrated, 8½ by 5½ inches, cloth, $4.00. This book affords a simple, clear explanation of the manufacture of the more important plastics, discusses the manufacturing problems, and their principal applications.

AMERICAN CHEMICAL INDUSTRY, 1912–1922. Volume 2. By W. Haynes. D. Van Nostrand Company, New York, 1945. 440 pages, illustrated, tables, 9¾ by 6½ inches, cloth, $8. This is the first of a projected six-volume history. The first five chapters describe the political and commercial setting of World War I period. The succeeding chapters cover developments in the field of critical raw materials such as nitrates. More than 100 pages of statistical data are appended.

APPLIED ENERGY CONVERSION. By B. G. A. Skrotzki and W. A. Vopat. McGraw-Hill Book Company, Inc., New York and London, 1945. 509 pages, illustrated, diagrams, charts, tables, 9 by 5¾ inches, cloth, $5. This text in power-plant engineering covers equipment and economics of industrial and central-station power plants. The newer developments in gas turbines and wind turbines, as well as special and European types of steam generators are included.

CALCULUS FOR PRACTICAL ENGINEERS. By A. Cibulka. Clarke and Courts, Houston, Tex., 1944. 100 pages, illustrated, diagrams, tables, 12 by 9½ inches, paper, $3. Basic equations and functions are given from algebra through trigonometry, analytic geometry, differential and integral calculus to differential equations. The processes of differentiation and integration are described in simple, practical language, with applications to a number of actual and varied engineering problems.

DIESEL-ELECTRIC PLANTS. 2nd edition. By E. J. Kates. American Technical Society, Chicago, 1945. 272 pages, illustrated, diagrams, charts, tables, 8½ by 5½ inches, cloth, $3.75. The purpose of this book is to deal with the co-ordinated aspects of the specialized subject, owing to the influence of the characteristics of the Diesel engine on the electric equipment involved. Important topics covered include voltage regulation, automatic synchronizing, engine governors, automatic controls, electric starting, installation and maintenance practice, and Diesel-electric locomotives.

FUNDAMENTAL THEORY OF SERVOMECHANISMS. By L. A. MacColl. D. Van Nostrand Company, New York, 1945. 130 pages, diagrams, charts, 9¼ by 6 inches, cloth, $2.25. This book is concerned mainly with the general theory of automatic control which is applicable to all linear continuously operating servomechanisms, with emphasis on its identity with the theory of feedback amplifiers. Some particular servomechanisms are discussed briefly.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

German "Fasteners" Industry. Bolts, Screws, Nuts and Rivets. Investigated by Roy H. Smith, Charles F. Newpher. July 6–20, 1945. American Institute of Bolt, Nut and Rivet Manufacturers. Cleveland, Ohio, 31 pages.

Educational Guide to Refrigeration and Air Conditioning Training Facilities in the United States. American Society of Refrigerating Engineers, New York, N. Y., 1945, 27 pages.

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